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Report of Investigations on the Mulberry-Dwarf Troubles—a Disease widely spread in Japan.

BY

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INTRODUCTION.

Since more than ten years there has been observed a disease of the mulberry, known as "Ishikubyô or shikuyōbyo"* attacking the leaves and branches, and checking growth and finally causing the death of the whole plant. When this disease once appears in a farm it spreads gradually, and finally attacking the entire farm, causes an immense loss to silkworm raisers by destroying the crop of the mulberry almost entirely. And although several persons have been engaged in seeking for a method of combatting the disease, none has as yet been successful, the disease in the meantime becoming more and more rampant, and calling forth an earnest demand for remedy on the part of the interested farmers. At last the Japanese government took the matter in hand, and a bill was passed through the Diet providing an annual expenditure of several thousand yen after April, 1897 for an investigation of the question. A board of specialists was appointed, consisting of the following gentlemen besides the present writer: Prof. C. Sasaki, Mr. J. Omori, Mr. I. Honda, Mr. N. Ichikawa, Mr. H. Nomura. Since then we have inspected the actual condition of the attacked farms in various localities and have instituted a systematic investigation of the problem from different points of view on an experiment farm at Nishigahara (a suburb of Tokyo) of about 275,000 sq. ft. in extent. In the mean while Mr. Nomura withdrew from the board, and Mr. Ichikawa

* Here translated "Mulberry-Dwarf Troubles."

having left for Europe, Prof. M. Miyoshi and Mr. K. Fujii were appointed to fill the vacancies. Mr. Ichikawa having recently returned was again added to the board.

From the beginning the writer took up the chemical side of the question. And as a preliminary step, comparative chemical analyses of healthy and attacked plants were made to ascertain the differential character of the latter, and as the writer believes himself to have been fortunate enough to discover the cause which induces the disease, he has decided to publish the result in order that others engaged in seeking for a remedy may avail themselves of it. The present paper is reproduced with the permission of the board from a report originally presented to it, and contains only the results obtained by myself. It must, however, be stated that most of the field experiments cited in this paper were conducted by Mr. Ichikawa for several years, either alone or in conjunction with the other members of the board. I must also note my indebtedness to other members of the board for supplying me with informations regarding the parasites, by which my view has directly or indirectly been strengthened.

There is no means of ascertainning the first origin of the disease in question, but it is probably not older than twenty or thirty years. As stated before, the disease has become especially malignant since over ten years ; and up to the present time, it has been reported from nearly all parts of the country. The damage has been particularly great in Ōita, Fukuoka, Kumamoto, Tottori, Shimane, Aichi, Shizuoka, Yamanashi, Tokyo, Saitama, Fukushima, and Gumma, and in some localities entire farms have been attacked by the disease, and the owners have been compelled to give up the cultivation of the mulberry. Localities where silkworm culture has recently come into practice appear to have a special propensity to the disease, and the newly started industry is very apt to receive a serious check from it. The entire annual damage for the whole country would doubtless amount to several millions of yen ; no wonder that the public has been awakened to it.

The different varieties of the mulberry are unequally liable to the disease. Generally speaking, those varieties which are esteemed for the quality of the leaves, large crop, and rapid growth have a greater propensity to the disease, while those which are charactarized by hard leaves, less sap, and slow

growth are comparatively free from it. Such varieties as Takasuke, Tsuruta, Hosoye, and Ichihei belong to the first category, Takasuke taking the lead, while Jūmonji and Rosô belong to the second. Moreover, the capacity for resistance towards the disease is subject to variation within the same variety, according to the treatment under which a plant has been brought up: plants that have deen induced to excessive growth with abundant soluble manures being more liable to attack, while those that have grown on lean soil among mountains or have not been manured are free from it. The quality of the soil also has a part in it, the disease appearing more commonly in those soils which are specially adapted for the growth of the mulberry. There is hardly an exception to this almost universal rule.

Before proceeding to the details of the investigation, a few words must be devoted to the manner in which the mulberry crop is gathered. In former times the plants were entirely left to their natural growth; but towards the end of the sixties the so-called cutting method was started and has now generally come in vogue. This consists in cutting the stem or shoots near the level of the ground in about the third year of the life of the plant, and letting new shoots come out from the stump. The season for cutting is usually from the earlier or later part of May to the earlier part of June, that is to say, at the time of the fullest development of the leaves. By August or September the new shoots reach the height of five or six feet, and these are again cut down in May of the next year. This way of treatment secures a large crop and lessens the injury from insects and fungi. Portability is also an advantage, though secondary.

There are several ways of cutting, but they may be reduced to three, which may be designated "low cutting," "medium cutting," and "high cutting." In the first, the stems are cut down immediately above the level of the ground, and in some cases the stumps are even covered with earth; in the second, the stumps are left about one foot high, while in the third, they are five to six feet. The relative advantage of these different ways of cutting depends upon local conditions, but it is a noteworthy fact that cases of the disease are especially numerous in plants subjected to low and medium cutting, while those subjected to high cutting are rarely attacked. Moreover, in those

localities where, owing to deep snow and economical circumstances, the old custom of leaving the plants to their natural growth is still adhered to, the disease is entirely unknown. This fact deserves especial emphasis, as having a close bearing on the true cause of the disease. Further, it deserves mention here that although if the shoots are cut in spring before the expansion of the leaves or in autumn after the fall of the leaves, the plants remain perfectly healthy, yet if the cutting takes place in the period of luxuriant growth, and especially in the so-called "late cutting" (i.e. in the latter part of July or in August), they are particularly liable to attack.

The first sign of the disease usually appears on new shoots springing from the stump. Namely, when these have reached the height of one foot or so the upper leaves either begin to shrivel or manifest other signs of debility, and as the shoots continue to lengthen, all the new leaves developed from them betray the same character. The diseased leaves may turn yellowish or remain dirty green, or may be indistinguishable in color from the healthy leaves, merely shrivelling up. In acute cases the leaves may all shrivel up in one year, but more usually only a few leaves near the top of the shoots first betray their debility, whence the disease spreads with each successive cutting, until in the course of a few years the entire plant is attacked or even dies off. The branches of the attacked plants remain usually slender, and the twigs and leaves are very numerous. Sometimes also, the branches lose their strength and become procumbent. In fact the diagnosis is somewhat variable, sometimes consisting in the paucity of the sap, as if the plants were grown in dry soils, or sometimes in the arrest of growth, as if the plants were still young; but the unfailing signs are the imperfect development and shrivelling of the leaves and the slenderness and dwarfed condition of the branches. Moreover, when a plant is once attacked recovery is possible only after two or three years of complete protection from the cutting.

Parasites have been hunted for in the leaves and branches of the diseased plants, but none have been found that can be regarded as having a causal connection with the disease. The roots of the diseased plants are usually in a decayed condition, and in more advanced cases even roots of a finger's thickness are completely rotten; and hence this decay of the roots has been

pointed out by some as the cause of the disease, and ascribed to mirco-organisms. But as observations were extended it became apparent that this decay of the roots is not the cause of the disease, but only a secondary phenomenon, due to want of nourishment; and we see that in the first stages of the affection, the roots do not show any perceptible difference from those of healthy plants, and only when the disease becomes more advanced do the roots decay. If the decay of the roots be the cause of the disease and due to micro-organisms, then it is hard to understand why the disease is almost confined to plants subjected to cutting, while those that are left to their natural growth are entirely free from it. The explanation appears to me to be that the decay of the roots is a result of the disease just as the imperfect growth of the leaves, and that both are effects of some underlying cause.

I shall not give a detailed diagnosis of the disease, and the reader is referred to the accompanying photographic reproductions. Numerous figures are also given in the chapter on the comparative analyses of healthy and affected plants, which have been made particularly exact and are thought sufficient to bring out the characteristics of the disease.

Previous to the appointment of the board before mentioned, several persons have been engaged on the same problem, but it is thought unnecessary to detail the results obtained by them. We must, however, acknowledge our indebtedness to the results obtained by Messrs. Ichikawa and Hori in the Agricultural Experiment Station of Aichi Prefecture, which are largely cited in the present paper. An extended inspection in different localities has convinced me that the present disease is confined to those plants which have been subjected to cutting; hence I was led to inquire into the effect of cutting on the plant. I found that during the growing period the reserve materials in the barks of the roots and stems are all transported to the growing parts and reach the minimum, and therefore if the plants are cut down in this period the new shoots would be forced to depend on an exceedingly small quantity of reserve materials. Hence the leaves would be only imperfectly developed, and the reserve materials would be exhausted before the plants can absorb and assimilate adequate nourishment from the soil and the atmosphere. Hence I concluded that the primary cause of the disease is to be sought in the practice now in vogue of subjecting the mulberry to re-

peated cuttings. This view has been tested by numerous experiments, and no doubt remains in my mind of its correctness. Moreover, experiments have shown that the same disease can also be induced by excessive plucking of the leaves, which would evidently have the same physiological effect as repeated cuttings of the stem. There is therefore no doubt that the present disease is caused by nothing else but the deficiency of reserve material. This, I believe, is proved by the analyses and experiments detailed in the following pages.

Chapter I. Chemical Composition of Healthy and Diseased Plants.

It is the object of this chapter to compare the chemical composition of healthy and diseased plants and to find out the characteristic differences between them. The samples used for analysis were all taken from the mulberry farm of the Tokyo Sericultural Experiment Station at Nishigahara.

1. TSURUTA. MAY 6, 1898.

	Healthy.	Diseased.
Number of stems	11	61
Number of leaves	627	1880
Average length of stem	96.1 cm.	45.
Total fresh weight of stems	656.6 g.	919.0.
Average fresh weight of 1 stem	59.7	15.1.
Total fresh weight of leaves	143.25	122.50.
Average fresh weight of 1 leaf	0.229	0.065.
Total dry weight of leaves	25.90	25.83.
Average dry weight of 1 leaf	0.041	0.04.
Moisture in fresh leaves	81.20	78.14.
Dry matter in fresh leaves	18.80	21.86.
Number of leaves on 1 stem	57.	31.
Dry matter in leaves of 1 stem	2.355	0.423.

In 100 parts of dry matter,

	Healthy leaves.	Diseased leaves.
Crude proteids	47.94	34.56
Crude fats	1.92	3.10

	Healthy leaves.	Diseased leaves.
Crude fibres Nitrogen-free extracts.	41.27	54.20
Crude ash (free from carbon and sand)	7.87	8.14
Total nitrogen.	**7.67**	**5.53**
Albuminoid nitrogen	**5.15**	**4.07**
Non-albuminoid nitrogen	**2.52**	**1.46**

In 100 parts of ash (free from carbon and sand),

	Healthy leaves.	Diseased leaves.
SiO_2	3.71	3.37
SO_3	6.23	3.85
P_2O_5	14.34	13.55
K_2O	35.20	30.53
CaO	15.20	18.90
MgO	8.22	10.46

The above results show that the diseased leaves contain less nitrogen but more fats and nitrogen-free extracts. In the ash ingredients, we find less sulphates and potash but more lime and magnesia in the diseased leaves.

2. TSURUTA OCTOBER 15, 1897.

	Healthy.	Diseased.
Number of leaves	100.	500.
Total fresh weight of leaves	322.	181.
Average fresh weight of 1 leaf	3.22	0.36
Total dry weight of leaves	96.35	67.68
Average dry weight of 1 leaf	0.96	0.135
Moisture in fresh leaves	70.00	62.6
Dry matter in fresh leaves	30.00	37.4

In 100 parts of dry matter,

	Healthy leaves.	Diseased leaves.
Crude proteids	26.88	23.13
Crude fats	5.80	4.40
Crude fibres	**8.74**	**6.70**
Nitrogen-free extracts	51.23	57.71
Crude ash (free from carbon and sand)	7.35	8.06

	Healthy leaves.	Diseased leaves.
Total nitrogen	4.30	3.70
Albuminoid nitrogen	3.60	3.00
Non-albuminoid nitrogen	0.70	0.70

In 100 parts of ash (free from carbon and sand),

	Healthy leaves.	Diseased leaves.
SiO_2	1.68	1.85
SO_3	2.32	2.64
P_2O_5	9.44	7.52
K_2O	27.40	14.10
CaO	22.10	38.60
MgO	9.60	12.20

In this case also the diseased leaves are exceedingly poor in nitrogen and fibres, and the ash contains less potash and phosphoric acid but more lime and magnesia.

3. HOSOYE. MAY 6, 1898.

	Healthy.	Diseased,
Number of stems	6	60.
Number of leaves	1345	3025.
Average length of 1 stem	195 cm.	82.5
Total fresh weight of stems	1231	1131.
Average fresh weight of 1 stem	205.0	18.85
Total fresh weight of leaves	1598.0	147.0
Average fresh weight of 1 leaf	0.111	0.049
Total dry weight of leaves	32.224	31.149
Average dry weight of 1 leaf	0.024	0.010
Moisture in fresh leaves	79.84	78.81
Dry matter in fresh leaves	20.16	21.19
Number of leaves on 1 stem	22.4	50.
Dry matter of leaves on 1 stem	5.371	0.519

In 100 parts of dry matter,

	Healthy leaves.	Diseased leaves.
Crude proteids	41.00	38.00
Crude fats	2.26	1.51
Crude fibres Nitrogen-free extracts	49.18	52.18

	Healthy leaves.	Diseased leaves.
Crude ash (free from carbon and sand)	7.56	8.16
Total nitrogen	6.56	6.08
Albuminoid nitrogen	4.08	3.94
Non-albuminoid nitrogen	2.48	2.14

In 100 parts of ash (free from carbon and sand),

	Healthy leaves.	Diseased leaves.
SiO_2	1.07	2.50
SO_3	5.15	4.27
P_2O_5	12.68	14.99
K_2O	36.30	32.00
CaO	17.23	15.75
MgO	8.45	7.26

This result is essentially similar to the preceding; but the difference between the healthy and diseased leaves is not so remarkable, the analysed leaves being still very young and the disease not much advanced.

4. Hosoye. October 15, 1897

	Healthy	Diseased
Number of shoots (one stock)	28	73.
Number of leaves	236	930.
Average length of 1 shoot	39 cm.	33.
Total fresh weight of shoots	62	66.
Average fresh weight of 1 shoot	2.22	0.90
Total dry weight of shoots	7.84	9.87
Average dry weight of 1 shoot	0.280	0.135
Moisture in shoots	87.35	85.05
Dry matter in shoots	12.65	14.95
Total fresh weight of leaves	87.0	117.0
Average fresh weight of 1 leaf	0.304	0.126
Total dry weight of leaves	18.348	30.835
Average dry weight of 1 leaf	0.066	0.033
Moisture in fresh leaves	78.90	73.64
Dry matter in fresh leaves	21.10	26.36
Number of leaves on 1 shoot	10.	13.
Dry matter in leaves of 1 shoot	0.695	0.422

The plants were cut down in early summer and once more August 30. The new shoots had reached the height of 30–40 cm on October 15, when they were cut down and dried for analysis. The shoots coming from unhealthy plants already showed distinct signs of the disease.

In 100 parts of dry matter,

	Healthy.		Diseased.	
	Leaves.	Shoots.	Leaves.	Shoots.
Crude proteids	33.00	19.75	23.13	20.56
Crude fats	6.19	2.35	4.96	3.70
Crude fibres	**10.53**	65.40	**7.26**	66.84
Nitrogen-free extracts	39.52		56.83	
Crude ash (free from carbon and sand)	11.76	12.50	7.82	8.90
Total nitrogen	**5.28**	**3.16**	**3.70**	**3.29**
Albuminoid nitrogen	**3.80**	**1.40**	**2.70**	**1.30**
Non-albuminoid nitrogen	**1.48**	**1.76**	**1.00**	**1.99**

In 100 parts of ash (free from carbon and sand),

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
SiO_2	4.87	1.02	4.00	1.90
SO_3	3.25	6.00	3.60	7.10
P_2O_5	8.56	8.10	11.80	10.90
K_2O	24.35	29.70	22.20	29.50
CaO	27.80	19.10	30.00	24.40
MgO	8.50	14.10	7.00	15.00

We see from the above tables that the diseased leaves are considerably poorer in nitrogen, fibres and ash. The diseased stems, on the contrary, are apparently rich in nitrogen; but this does not mean any absolute richness in nitrogen, because the development of fibres in the diseased stems was very bad, in consequence of which the persentage of nitrogen was much increased. If we compare the absolute quantities of nitrogen, then, of course, we should get a remarkable difference. We observe also a great difference between the ash contents of the healthy and diseased plants. These facts indicate that diseased

plants contained a far smaller quantity of reserve materials in the roots, and that the new shoots coming out after the cutting suffered from the deficiency of nutriment, and consequently became diseased.

5. YOTSUME. MAY 22, 1898.

	Healthy	Diseased.
Number of stems	4.	35.
Number of leaves	553.	1387.
Average length of stems	66. cm.	45.
Total fresh weight of stems	117.	210.
Average fresh weight of 1 stem	29.25	6.00
Total fresh weight of leaves	100.85	98,65
Average fresh weight of 1 leaf	0.181	0.071
Total dry weight of leaves	28.612	27.024
Average dry weight of 1 leaf	0.051	0.020
Moisture in fresh leaves	71.63	72.60
Dry matter in fresh leaves	28.37	27.40
Number of leaves on 1 stem	140.	40.
Dry matter in leaves of 1 stem	7.158	0.772

In 100 parts of dry matter,

	Healthy leaves.	Diseased leaves.
Crude proteids	28.75	27.94
Crude fats	3.83	3.45
Crude fibres Nitrogen-free extracts	59.66	60 07
Crude ash (free from carbon and sand)	7.76	8.54
Total nitrogen	**4.60**	**4.47**
Albuminoid nitrogen	**4.34**	**4.15**
Non-albuminoid nitrogen	**0.26**	**0.32**

In 100 parts of ash (free from carbon and sand),

	Healthy leaves	Diseased leaves
SiO_2	3.44	4.60

	Healthy leaves.	Diseased leaves.
SO_3	3.26	3.34
P_2O_5	13.86	13.14
K_2O	31.81	28.30
CaO	25.07	23.08
MgO	11.48	11.60

In this case the difference in nitrogen is not so remarkable, the leaves being too young.

6. TAKASUKE. MAY 22, 1898.

	Healthy.	Diseased.
Number of stem	3.	21.
Number of leaves	408.	941.
Average length of 1 stem	90.	45.
Total fresh weight of stems	150.	182.
Average fresh weight of 1 stem	50.00	8.70
Total fresh weight of leaves	154.5	132.35
Average fresh weight of 1 leaf	0.376	0.141
Total dry weight of leaves	35.261	42.321
Average dry weight of 1 leaf	0.111	0.045
Moisture in fresh leaves	70.50	68.00
Dry matter in fresh leaves	29.50	32.00
Number of leaves on 1 stem	136.	45.
Dry matter in leaves of 1 stem	15.087	2.015

In 100 parts of dry matter,

	Healthy leaves.	Diseased leaves.
Crude proteids	23.75	18.44
Crude fats	3.46	3.34
Crude fibres	**9.61**	**8.60**
Nitrogen-free extracts	56.84	63.49
Crude ash (free from carbon and sand)	6.34	6.13
Total nitrogen	**3.80**	**2.95**
Albuminoid nitrogen	**3.05**	**2.79**
Non-albuminoid nitrogen	**0.75**	**0.16**

In 100 parts of ash (free from carbon and sand),

	Healthy leaves.	Diseased leaves.
SiO_2	2.64	3.77
SO_3	3.64	4.00
P_2O_5	17.90	19.02
K_2O	28.51	29.43
CaO	23.64	23.00
MgO	10.44	12.82

The diseased leaves contain here a far smaller quantity of nitrogen and fibres than in the former case; no remarkable difference in the ash ingredients is to be observed.

7. TAKASUKE. JULY 9, 1898.

	Healthy.	Diseased.
Number of shoots (one stock)	51.	68.
Number of leaves	910.	1297.
Average length of 1 shoot	30.	18.
Total fresh weight of shoots	277.75	70.35
Average fresh weight of 1 shoot	5.446	2.035
Total dry weight of shoots	44.329	16.242
Average dry weight of 1 shoot	0.869	0.239
Moisture in shoots	84.04	78.00
Dry matter in shoots	15.96	22.00
Total fresh weight of leaves	355.20	142.71
Average fresh weight of 1 leaf	0.39	0.11
Total dry weight of leaves	82.72	44.023
Average dry weight of 1 leaf	0.099	0.034
Moisture in fresh leaves	76.70	69.15
Dry matter in fresh leaves	23.30	30.85
Number of leaves on 1 shoot	18.	19.
Dry matter in leaves of 1 shoot	1.622	0.647

In 100 parts of dry matter,

	Healthy.		Diseased.	
	Leaves.	Shoots.	Leaves.	Shoots.
Crude proteids	30.50	15.38	23.13	14.44
Crude facts	2.84	0.83	3.05	2.20

	Healthy.		Diseased.	
	Leaves.	Shoots.	Leaves.	Shoots.
Crude fibres	11.14	46.30	8.03	40.14
Nitrogen-free extracts	47.26	31.54	58.90	36.93
Ash (free from carbon and sand)	8.26	5.95	6.89	6.29
Total nitrogen	4.88	2.46	3.70	2.31
Albuminoid nitrogen	3.85	1.10	3.35	1.20
Non-albuminoid nitrogen	1.03	1.36	0.36	1.11

In 100 parts of ash (free from carbon and sand),

	Healthy.		Diseased.	
	Leaves.	Shoots.	Leaves.	Shoots.
SiO_2	4.68	1.19	4.83	2.90
SO_3	2.60	4.00	2.81	4.20
P_2O_5	14.60	14.60	11.90	18.87
K_2O	21.15	38.50	18.70	31.30
CaO	27.21	22.26	32.43	28.90
MgO	10.13	13.70	14.42	16.43

As the shoots were very young, being developed after cutting at the end of May they were especially well fitted for comparison. The diseased leaves were remarkably poor in nitrogen, fibres, and ash, and among the ash ingredients, there were much less phosphoric acid and potash, and much more lime and magnesia than in the healthy leaves. This result much resembles the case of Hosoye (II), the conditions of development being the same in both. In the diseased stems we find also less fibres, but no remarkable difference is to be found in the quantity of nitrogen.

8. TAKASUKE. SEPTEMBER 9, 1898.

	Healthy.	Diseased.
Number of stems	4.	4.
Number of leaves	143.	1056.
Average length of 1 stem	180.	90.
Total fresh weight of stems	403.	145.
Average fresh weight of 1 stem	101.	365.
Total dry weight of stems	118.25	44.24

	Healthy.	Diseased.
Average dry weight of 1 stem	29.56	11.06
Moisture in stems	70.66	69.49
Dry matter in stems	29.34	30.51
Total fresh weight of leaves	367.5	172.00
Average fresh weight of 1 leaf	2.57	0.162
Total dry weight of leaves	124.08	81.35
Average dry weight of 1 leaf	0.868	0.076
Moisture in fresh leaves	66.23	52.70
Dry matter in fresh leaves	33.77	47.30
Number of leaves on 1 stem	36.	266.
Dry matter in leaves of 1 stem	31.02	20.34

In 100 parts of dry matter,

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
Crude proteids	22.88	5.38	20.25	10.07
Crude fats	7.34	1.10	4.34	1.57
Crude fibres	**9.59**	**54.60**	**7.11**	**50.54**
Nitrogen-free extracts	52.42	34.58	60.88	32.56
Ash (free from carbon and sand)	7.77	4.34	7.42	5.27
Total nitrogen	**3.66**	**0.86**	**3.24**	**1.61**
Albuminoid nitrogen	**3.37**	**0.54**	**2.98**	**0.98**
Non-albuminoid nitrogen	**0.29**	**0.32**	**0.26**	**0.63**

In 100 parts of ash (free from carbon and sand)

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
SiO_2	1.35	0.94	1.54	1.36
SO_3	1.22	2.00	1.90	4.00
P_2O_5	6.41	8.90	6.10	8.74
K_2O	19.20	39.60	18.10	34.90
CaO	40.28	18.80	35.54	16.62
MgO	13.78	7.04	18.65	12.46

9. JŪMONJI. JULY 9, 1898.

	Healthy.	Diseased.
Number of shoots	36.	48.
Number of leaves	261.	547.
Average length of 1 shoot	16.5	12.
Total fresh weight of shoots	90.	48.7
Average fresh weight of 1 shoot	2.50	1.02
Total dry weight of shoots	10.765	5.532
Average dry weight of 1 shoot	0.299	0.115
Moisture in shoots	88.04	88.60
Dry matter in shoots	11.96	11.40
Total fresh weight of leaves	256.20	136.15
Average fresh weight of 1 leaf	0.215	0.249
Total weight of leaves	29.425	13.605
Average dry weight of 1 leaf	0.113	0.025
Moisture in fresh leaves	88.50	90.00
Dry matter in fresh leaves	11.50	10.00
Number of leaves on 1 shoot	7.	11.
Dry matter in leaves of 1 shoot	0.817	0.284

In 100 parts of dry matter,

	Healthy.		Diseased.	
	Leaves.	Shoots.	Leaves.	Shoots.
Crude proteids	36.63	21.75	32.50	26.65
Crude fats	4.26	2.20	8.08	2.54
Crude fibres	**11.04**	**36.72**	**9.56**	**27.67**
Nitrogen-free extracts	37.67	31.85	45.04	31.52
Ash (free from carbon and sand)	10.40	7.48	9.82	11.64
Total nitrogen	**5.86**	**3.48**	**5.20**	**4.26**
Albuminoid nitrogen	**4.18**	**1.47**	**4.10**	**1.79**
Non-albuminoid nitrogen	**1.68**	**2.01**	**1.10**	**2.47**

In 100 parts of ash (free from carbon, carbonic acid, and sand),

	Healthy leaves.	Diseased leaves.
SiO_2	1.90	2.10
SO_3	2.43	2.70
P_2O_5	20.40	20.60
K_2O	23.63	24.66
CaO	28.10	26.77
MgO	8.85	12.56

10. JŪMONJI. SEPTEMBER 9, 1898.

	Healthy.	Diseased.
Number of stems	3.	10.
Number of leaves	135.	374.
Average length of 1 stem	150.	75.
Total fresh weight of stems	175.5	120.
Average fresh weight of 1 stem	58.5	12.00
Total dry weight of stems	51.566	32.277
Average dry weight of 1 stem	17.188	3.328
Moisture in stems	70.60	72.27
Dry matter in stems	29.40	27.73
Total fresh weight of leaves	159.	129.
Average fresh weight of 1 leaf	1.178	0.345
Total dry weight of leaves	55.266	47.534
Average dry weight of 1 leaf	0.409	0.127
Moisture in fresh leaves	65.24	63.12
Dry matter in fresh leaves	34.76	36.88
Number of leaves on 1 stem	45.	73.
Dry matter in leaves of 1 stem	18.422	4.753

In 100 parts of dry matter,

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
Crude proteids	22.38	5.31	16.50	5.44
Crude fats	7.29	1.00	6.72	1.30
Crude fibres	9.32	59.00	9.73	56.20

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
Nitrogen-free extracts	50.88	30.36	60.50	33.19
Ash (free from carbon and sand)	10.13	4.33	6.55	3.87
Total nitrogen	3.58	0.85	2.64	0.87
Albuminoid nitrogen	3.10	0.57	2.32	0.66
Non-albuminoid nitrogen	0.48	0.28	0.31	0.21

In 100 parts of ash (free from carbon and sand),

	Healthy.		Diseased.	
	Leaves.	Stems.	Leaves.	Stems.
SiO_2	1.42	1.40	1.78	2.31
SO_3	1.70	1.60	1.70	2.60
P_2O_5	6.57	7.80	8.20	9.75
	23.92	31.60	26.50	24.46
CaO	39.67	24.76	36.87	23.26
MgO	12.05	9.14	15.55	11.74

The above mentioned results of 10 analyses will be sufficient to show the difference in chemical composition of the healthy and diseased plants. The following tables show the average of the above 10 analyses.

Average of the above 10 analyses.

	Healthy.	Diseased	Ratio.
Average length of 1 stem	95.8 cm.	49.5	100 : 51.7
Average fresh weight of 1 stem	57.07	11.10	100 : 19.4
Average dry weight of 1 stem	9.64	2.98	100 : 31.0
Moisture in stems	80.16	78.68	100 : 98.2
Dry matter in stems	19.84	21.32	100 : 107.3
Number of leaves on 1 stem	75.	57.	100 : 76.0
Dry matter in leaves of 1 stem	9.17	3.35	100 : 36.6
Average fresh weight of 1 leaf	0.954	0.168	100 : 17.6
Average dry weight of 1 leaf	0.275	0.052	100 : 18.8
Moisture in fresh leaves	74.87	70.88	100 : 94.7
Dry matter in fresh leaves	25.13	29.12	100 : 116.0

Average composition of leaves.

	Healthy.	Diseased.	Ratio.
Moisture	74.87	70.88	100 : 94.7
Dry matter	25.13	29.12	100 : 116.0

In 100 parts of dry matter,

Crude proteids	31.47	25.76	100 : 81.8
Crude fats	4.42	3.80	100 : 86.0
Crude fibres	10.00	8.14	100 : 81.4
Nitrogen-free extracts	47.97	57.60	100 : 120.0
Ash (free from carbon and sand)	8.52	7.75	100 : 91.0
Total nitrogen	5.02	4.12	100 : 81.8
Albuminoid nitrogen	3.85	3.34	100 : 86.6
Non-albuminoid nitrogen	1.17	0.78	100 : 66.6

In 100 parts of ash (free from carbon and sand),

SiO_2	2.68	3.03	100 : 113.1
SO_3	3.18	3.09	100 : 97.2
P_2O_5	12.48	12.69	100 : 101.6
K_2O	27.15	25.05	100 : 92.3
CaO	26.63	28.09	100 : 105.5
MgO	10.15	12.25	100 : 120.6

Average composition of stems.

	Healthy.	Diseased.	Ratio.
Moisture	80.14	78.68	100 : 98.2
Dry matter	19.86	21.32	100 : 107.3

In 100 parts of dry matter,

Crude proteids	13.51	15.43	100 : 114.2
Crude fats	1.50	2.26	100 : 151.0
Crude fibres	49.16	43.64	100 : 88.8

	Healthy.	Diseased.	Ratio.
Nitrogen-free extracts	32.08	33.55	100 : 104.6
Ash (free from carbon and sand)	6.92	7.19	100 : 103.9
Total nitrogen	2.16	2.47	100 : 114.2
Albuminoid nitrogen	1.02	1.19	100 : 117.0
Non-albuminoid nitrogen	1.14	1.28	100 : 112.3

In 100 parts of ash (free from carbon and sand),

SiO_2	1.14	2.12	100 : 186.0
SO_3	3.40	4.48	100 : 132.0
P_2O_5	9.86	12.07	100 : 123.0
K_2O	34.85	32.59	100 : 93.5
CaO	21.23	23.30	100 : 110.0
MgO	11.60	13.90	100 : 126.0

We see from the above tables that the average length of the diseased stems is nearly half that of the healthy ones, and the fresh weight nearly $\frac{1}{6}$. Both the diseased stems and leaves contain a little less moisture, but the difference is not so remarkable, being only 2% in the stems and 5% in the leaves. The total dry weight of the leaves of one diseased stem is about $\frac{1}{3}$ of those of a healthy one, while the average dry weight of one diseased leaf is far less than that of a healthy one, being only $\frac{1}{6}$ of the latter.

Comparing the chemical constituents of the leaves, we find that nitrogen compounds, fibres, and fats are remarkably deficient in the diseased ones, being nearly $\frac{4}{5}$ of the healthy, while, on the contrary, nitrogen-free extracts are more abundant. The reason why the leaves remain so small and shrivel may be due to the deficiency of nitrogen compounds in the living cells, in consequence of which the chemical activity of the living protoplasm must be much retarded, and also to the bad development of fibres. The assimilation products in the leaves remain unchanged, and the conversion by the living protoplasm, of soluble sugars into cellulose seems to be especially retarded.

It is a most remarkable fact that the diseased leaves contain only $\frac{2}{3}$ of the non-albuminoid nitrogen compounds, compared with the healthy ones. The decrease of non-albuminoid nitrogen

in the leaves is a clear evidence of the retardation of vital activity.

The deficiency of nitrogen compounds in the diseased leaves is not caused by an insufficient supply of nitrogen manures, since the disease is always rampant on fertile soils and on soils treated with soluble manures. The principal cause of the retardation of vital activity must be either the cutting of the stems in the growing season, or the exhaustion of reserve materials in the roots and stems by excessive drain of the leaves. This question will be discussed fully in the next chapter. As regards the ash contents, we find on the average less in the diseased leaves, but sometimes there are exceptions, so that we can not draw any definite conclusion on this point. In the ash of the diseased leaves we generally find less silica, sulphuric acid and phosphoric acid and more lime and magnesia, but the difference is not very regular. At any rate, we may conclude that the disease is not caused by the deficiency of some special mineral nutriments in the soil, and the difference in the ash ingredients may be simply an effect of the disease.

The diseased stems contain also less fibres, but the percentage of nitrogen is apparently higher; this may be explained by the fact that in the healthy stems the development of fibres is enormous, in consequence of which the percentage of nitrogen seems apparently lowered. There must of course be remarkable difference in the absolute quantity of nitrogen contained in one stem. No regular difference is found in the ash ingredients of the diseased stems.

Chapter II. On the Reserve Materials of the Mulberry Tree and their Relation to the Disease.

In this chapter, the reserve materials of the mulberry tree, their migration, and their relation to cutting is fully discussed. The samples used for analysis were all taken from the mulberry farm of the Tokyo Sericultural Experiment Station at Nishigahara. Three varieties, Takasuke, Tsuruta, and Jūmonji, were selected for this purpose. They were all under the same treatment in the same farm, and eight years old (low cutting). Five plants of

each variety which were very similar in all respects, were analysed at different seasons of the year, and the quantity of the reserve materials, the rapidity of their migration, etc. were compared. As the cutting in the growing season has a special relation to the disease, it was my chief aim to find out the relation of the reserve materials to the period of cutting, and finally the conclusion was arrived at that the cutting in the growing season is the principal cause of the disease.

I. TAKASUKE.

(1). April 28, 1899.

		Fresh weight.	Dry weight.	Dry matter %	Moisture %
Roots	wood	2895 g.			
	bark	864	240.7	27.9	72.1
Stems	wood	812			
	bark	420	132.6	31.6	68.4
Leaves [1]		282	48.2	17.1	82.9

[1] As the time of gathering was a little too late, the leaves began to develop.

In 100 parts of dry matter,

	Root bark.	Stem bark.	Leaves.
Crude proteids	16.0	17.1	40.0
Crude fats	8.3	3.1	—
Crude fibres	27.3	35.9	—
Total carbohydrates (as starch)	18.4	—	—
Crude ash	8.2	6.7	10.9
Nitrogen-free extracts	40.2	37.2	—
Total nitrogen	2.56	2.74	6.40
Albuminoid nitrogen	1.38	1.60	4.10
Non-albuminoid nitrogen	1.18	1.14	2.30

(2) May 18, 1899.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	3500.0			
	bark	1174.5	341.3	20.5	79.5
Stems	wood	1064.2			
	bark	456.5	146.2	32.0	68.0
New stems		305.2	43.0	14.1	85.9
Leaves		1220.7	266.8	21.9	

In 100 parts of dry matter,

	Root bark.	Stem bark.	New stem.	Leaves.
Crude proteids	10.8	11.9	19.38	31.25
Crude fats	9.1	3.5	—	—
Crude fibres	30.2	32.7	—	—
Total carbohydrates	14.0	—	—	—
Crude ash	7.3	6.2	8.3	8.8
Nitrogen-free extracts	42.6	45.7	—	—
Total nitrogen	1.73	1.91	3.10	5.00
Albuminoid nitrogen	1.12	1.30	—	3.40
Non-albuminoid nitrogen	0.61	0.61	—	1.60

(3). July 11, 1899.

Number of new shoots 32; average length of 1 shoot 50 cm.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	2000.0			
	bark	717.2	186.5	26.0	74.0
New shoots		116.3	19.6	16.8	83.2
Leaves		214.1	55.4	25.9	74.1

In 100 parts of dry matter,

	Root bark.	New shoots.	Leaves.
Crude proteid	8.0	10.77	33.0
Crude fats	10.5	—	—
Crude fibres	33.1	—	—
Total carbohydrates	12.5	—	—
Crude ash	7.7	10.7	11.0
Nitrogen-free extracts	40.7	—	—
Total nitrogen	1.28	1.72	5.28
Albuminoid nitrogen	0.95	—	—
Non-albuminoid nitrogen	0.33	—	—

(4). November 28, 1899.

Number of stems 21.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture. %.
Roots	wood	2207.5			
	bark	660.8	269.2	40.7	59.3
Stems	wood	357.5			
	bark	172.1	72.7	42.2	57.8

In 100 parts of dry matter,

	Root bark.	Stem bark.
Crude proteids	9.3	16.4
Crude fats	6.6	5.3
Crude fibres	25.1	33.4
Total carbohydrates	28.2	18.6
Crude ash	7.1	6.7
Nitrogen-free extracts	51.9	38.2
Total nitrogen	1.49	2.62
Albuminoid nitrogen	0.92	1.79
Non-albuminoid nitrogen	0.57	0.83

(5). December 2, 1899. (no-cutting)

Number of stems 24.

		Fresh weight.	Dry weight.	Dry matter %.	moister %.
Roots	wood	4962.4			
	bark	1791.3	591.1	33.0	67.0
Stems	wood	5229.4			
	bark	1715.0	919.3	53.7	46.3

In 100 parts of dry matter,

	Root bark.	Stem bark.
Crude proteids	12.3	14.3
Crude fats	6.8	5.6
Crude fibres	27.9	36.3
Total carbohydrates	21.6	12.9
Crude ash	7.8	5.6
Nitrogen-free extracts	45.2	38.2
Total nitrogen	1.97	2.28
Albuminoid nitrogen	1.16	1.51
Non-albuminoid nitrogen	0.81	0.77

II. TSURUTA.

(1). April 28, 1899.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	3120.0			
	bark	1000.0	338.3	33.8	66.2
Stems	wood	610.0			
	bark	285.0	97.5	34.2	65.8
Leaves		231.0	40.8	17.7	82.3

In 100 parts of dry matter,

	Root bark.	Stem bark	Leaves.
Crude proteids	13.4	12.5	42.5
Crude fats	10.5	4.4	—
Crude fibres	25.8	34.2	—

Total carbohydrates	20.0	—	—
Crude ash	7.7	7.0	10.0
Nitrogen-free extracts	42.6	41.9	—
Total nitrogen	2.15	2.00	6.80
Albuminoid nitrogen	1.20	1.40	—
Non-albuminoid nitrogen	0.95	0.60	—

(2). May 28, 1899.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	2520.0			
	bark	866.2	293.4	66.1	33.9
Stems	wood	1271.7			
	bark	370.9	125.6	66.0	34.0
New stems		415.2	80.5	80.6	19.4
Leaves		1473.7	377.1	74.4	25.6

In 100 parts of dry matter,

	Root bark.	Stem bark.	New bark.	Leaves.
Crude proteids	8.6	9.3	13.75	26.9
Crude fats	11.5	4.5	—	—
Crude fibres	30.0	31.8	—	—
Total carbohydrates	14.4	—	—	—
Crude ash	8.7	6.9	7.0	8.6
Nitrogen-free extracts	41.2	47.5	—	—
Total nitrogen	1.37	1.48	2.2	4.3
Albuminoid nitrogen	0.95	1.00	1.1	—
Non-albuminoid nitrogen	0.42	0.48	1.1	—

(3). July 11, 1899.

Number of new shoots 27; average length of one shoot 60 cm.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	3380.0			
	bark	945.8	268.8	28.4	71.6
New shoots		311.5	50.4	16.2	83.8
Leaves		433.6	92.1	21.2	78.8

In 100 parts of dry matter,

	Root bark.	New shoots.	Leaves.
Crude proteids	8.9	10.4	32.7
Crude fats	12.6	—	—
Crude fibres	34.0	—	—
Total carbohydrates	10.9	—	—
Crude ash	10.1	7.2	10.2
Nitrogen-free extracts	34.6	—	—
Total nitrogen	1.42	1.67	5 23
Albuminoid nitrogen	0.92	—	—
Non-albuminoid nitrogen	0.50	—	—

(4). December 2, 1899.

Number of stems 34.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	4558.5			
	bark	1493.1	602.6	41.7	58.3
Stems	wood	742.4			
	bark	313.4	172.3	54.9	45.1

In 100 parts of dry matter,

	Root bark.	Stem bark
Crude proteids	10.7	12.9
Crude fats	9.1	5.9
Crude fibres	26.5	30.7
Total carbohydrates	24.0	16.4
Crude ash	7.4	6.3
Nitrogen-free extract	46.3	44.2
Total nitrogen	1.71	2.07
Albuminoid nitrogen	1.02	1.48
Non-albuminoid nitrogen	0.69	0.59

(5). December 6, 1899. (*no cutting.*)

Number of stems 10.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	4135.1			
	bark	1495.7	534.0	35.7	64.3
Stems	wood	2368.4			
	bark	806.9	381.0	47.2	52.8

In 100 parts of dry matter,

	Root bark.	Stem bark.
Crude proteids	13.3	13.4
Crude fats	11.2	5.9
Crude fibres	27.8	37.1
Total carbohydrates	17.4	14.7
Crude ash	6.6	6.4
Nitrogen-free extracts	41.1	37.2
Total nitrogen	2.13	2.14
Albuminoid nitrogen	0.99	1.36
Non-albuminoid nitrogen	1.14	0.78

III. JŪMONJI.

(1). April 28, 1899.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %
Roots	wood	3158.0			
	bark	778.0	311.1	40.0	60.0
Stems	wood	660.0			
	bark	295.0	90.2	30.6	69.4
Leaves		130.0	25.5	19.6	80.4

In 100 parts of dry matter,

	Root bark.	Stem bark.	Leaves.
Crude proteids	11.3	15.1	36.0
Crude fats	10.4	5.5	—
Crude fibres	25.4	36.3	—
Total carbohydrates	23.6	—	—

Crude ash	7.7	7.5	10.7
Nitrogen-free extracts	45.2	35.6	—
Total nitrogen	1.80	2.41	5.76
Albuminoid nitrogen	1.10	1.82	4.00
Non-albuminoid nitrogen	0.70	0.59	1.76

(2). May 29, 1899.

		Fresh weight.	Dry weight.	Dry matter %	Moisture %
Roots	wood	1180.0			
	bark	1018.5	382.3	37.5	62.5
Stems	wood	1176.1			
	bark	435.1	149.6	34.4	65.6
New stems		315.1	50.3	16.0	84.0
Leaves		1200.5	316.4	26.4	73.6

In 100 parts of dry matter,

	Root bark.	Stem bark.	New stems.	Leaves.
Crude proteids	8.1	10.2	14.4	25.0
Crude fats	10.6	5.3	—	—
Crude fibres	30.8	28.6	—	—
Total carbohydrates	16.9	—	—	—
Crude ash	7.4	6.3	8.0	10.7
Nitrogen-free extracts	43.1	49.6	—	—
Total nitrogen	1.29	1.63	2.30	4.00
Albuminoid nitrogen	0.95	1.10	1.30	3.30
Non-albuminoid nitrogen	0.34	0.53	1.00	0.70

(3). July 11, 1899.

Number of new shoots 27; average length of one shoot 55 cm.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	5650.0			
	bark	1307.8	412.2	31.5	68.5
New shoots		198.5	28.4	14.3	85.7
Leaves		255.3	49.9	19.5	80.5

In 100 parts of dry matter,

	Root bark.	New shoots.	Leaves.
Crude proteids	8.0	12.88	32.75
Crude fats	11.5	—	—
Crude fibres	34.9	—	—
Total carbohydrates	14.6	—	—
Crude ash	9.2	9.10	11.9
Nitrogen-free extracts	36.4	—	—
Total nitrogen	1.28	2.06	5.24
Albuminoid nitrogen	0.79	1.03	—
Non-albuminoid nitrogen	0.49	1.03	—

(4). December 2, 1899.

Number of stems 21.

		Fresh weight.	Dry weight.	Dry matter %.	Moisture %.
Roots	wood	6233.0			
	bark	1378.2	605.3	43.9	56.1
Stems	wood	793.6			
	bark	383.7	183.0	47.7	52.3

In 100 parts of dry matter,

	Root bark.	Stem bark.
Crude proteids	9.7	12.9
Crude fats	10.0	6.2
Crude fibres	28,4	29.1
Total carbohydrates	25.5	17.9
Crude ash	7.0	6.0
Nitrogen-free extracts	44.9	45.8
Total nitrogen	1.55	2.07
Albuminoid nitrogen	0.92	1.48
Non-albuminoid nitrogen	0.63	0.59

From the above mentioned data, we have prepared the following tables, from which one can clearly see that the reserve materials in the barks of roots and stems rapidly decrease with the development of the leaves, and that at the time of cutting, i.e. May 18-28, they reach the minimum. Compare also Plates XIX–XXX.

I. TAKASUKE.

A) Root bark.

	April. 28	May 18.	July 11.	November 28.	December 2. (no cutting)
Moisture	72.1	79.5	74.0	59.3	67.0
Dry matter	27.9	20.5	26.0	40.7	33.0

In 100 parts of dry matter,

Crude proteids	21.1	10.8	8.0	9.3	12.3
Crude fats	8.3	9.1	10.5	6.6	6.8
Crude fibres	27.3	30.2	33.1	25.1	27.9
Total carbohydrates	18.4	14.0	12.5	28.2	21.6
Crude ash	8.2	7.3	7.7	7.1	7.8
Nitrogen-free extracts	40.2	42.6	40.7	51.9	45.2
Total nitrogen	3.38	1.73	1.28	1.49	1.97
Albuminoid nitrogen	1.82	1.12	0.95	0.92	1.16
Non-albuminoid nitrogen	1.56	0.61	0.33	0.57	0.81

Total nitrogen.	100.0	51.2	37.9	44.1	58.3
Albuminoid nitrogen	53.9	33.1	28.1	27.2	34.3
Non-albuminoid nitrogen	46.1	18.1	9.8	16.9	24.0

Total nitrogen	100.0	51.2	37.9	44.1	58.3
Albuminoid nitrogen	100.0	61.5	52.2	50.6	63.7
Non-albuminoid nitrogen	100.0	39.1	21.2	36.5	51.9

B) Stem bark.

	April 28.	May 18.	November 28.	December 2. (no cutting)
Moisture	68.4	68.0	57.8	46.3
Dry matter	31.6	32.0	42.2	53.7

In 100 parts of dry matter,

Crude proteids	22.3	11.9	16.4	14.3
Crude fats	3.1	3.5	5.3	5.6
Crude fibres	35.9	32.7	33.4	36.3
Total carbohydrates	—	—	18.6	12.9
Crude ash	6.7	6.2	6.7	5.6
Nitrogen-free extracts	37.2	45.7	38.2	38.2
Total nitrogen	**3.56**	**1.91**	**2.62**	**2.28**
Albuminoid nitrogen	**2.08**	**1.30**	**1.79**	**1.51**
Non-albuminoid nitrogen	**1.48**	**0.60**	**0.83**	**0.77**

Total nitrogen.	**100.0**	**53.7**	**73.6**	**64.0**
Albuminoid nitrogen	**58.4**	**36.5**	**50.3**	**42.4**
Non-albuminoid nitrogen	**41.6**	**17.2**	**23.3**	**21.6**

Total nitrogen.	**100.0**	**53.7**	**73.6**	**64.0**
Albuminoid nitrogen	**100.0**	**62·5**	**86.6**	**72.6**
Non-albuminoid nitrogen	**100.0**	**41.3**	**56.1**	**52.0**

II. Tsuruta.

A) Root bark.

	April 28.	May 29.	July 11.	December 2.	December 6. (no cutting)
Moisture	66.2	66.1	71.6	58.3	64.3
Dry matter	33.8	33.9	28.4	41.7	35.7

In 100 parts of dry matter,

Crude proteids	17.4	8.6	8.9	10.7	13.3
Crude fats	10.5	11.5	12.6	9.1	11.2
Crude fibres	25.8	30.0	34.0	26.5	27.8
Total carbohydrates	20.0	14.4	10.9	24.0	17.4
Crude ash	7.7	8.7	10.1	7.4	6.6
Nitrogen-free extracts	42.6	41.2	34.6	46.3	41.1
Total nitrogen	2.79	1.37	1.42	1.71	2.13
Albuminoid nitrogen	1.56	0.95	0.92	1.02	0.99
Non-albuminoid nitrogen	1.28	0.42	0.50	0.69	1.14

Total nitrogen	100.0	49.1	50.9	61.3	76.3
Albuminoid nitrogen	55.8	34.1	33.0	36.6	35.5
Non-albuminoid nitrogen	44.2	15.0	17.9	24.7	40.8

Total nitrogen	100.0	49.1	50.9	61.3	76.3
Albuminoid nitrogen	100.0	60.9	59.0	65.4	63.5
Non-albuminoid nitrogen	100.0	34.1	40.7	56.1	92.7

B) Stem bark.

	April 28.	May 29.	December 2.	December 6. (no cutting)
Moisture	65.8	66.0	45.1	52.8
Dry matter	34.2	34.0	54.9	47.2

In 100 parts of dry matter,

Crude proteids	16.5	9 3	12.9	13.4
Crude fats	4.4	4.5	5.9	5.9
Crude fibres	34.2	31.8	30 7	37.1
Total carbohydrates	—	—	16.4	14.7
Crude ash	7.0	6.9	6.3	6.4
Nitrogen-free extracts	41.9	47.5	44.2	37.2
Total nitrogen	2.64	1.48	2.07	2.14
Albuminoid nitrogen	1.85	1.00	1.48	1.36
Non-albuminoid nitrogen	0.79	0.48	0.59	0.78

Total nitrogen	100 0	56.6	78.4	81.1
Albuminoid nitrogen	70 0	37.9	56.6	51.5
Non-albuminoid nitrogen	30.0	18.7	21.8	29.6

Total nitrogen	100 0	56.6	78.4	81.1
Albuminoid nitrogen	100.0	54 0	80.0	73.5
Non-albuminoid nitrogen	100 0	60 8	74.7	98.7

III JŪMONJI.

A) Root bark.

	April 28.	May 29.	July 11.	December 3.
Moisture	60.0	62.5	68.5	56.1
Dry matter	40.0	37.5	31.5	43.9

In 100 parts of dry matter,

Crude proteids	13.5	8.1	8.0	9.7
Crude fats	10.4	10.6	11.5	10.0
Crude fibres	25.4	30.8	34.9	28.4
Total carbohydrates	23.6	16.9	14.6	25.5
Crude ash	7.7	7.4	9.2	7.0
Nitrogen-free extracts	45.2	43.1	36.4	44.9
Total nitrogen	2.16	1.29	1.28	1.55
Albuminoid nitrogen	1.32	0.95	0.79	0.92
Non-albuminoid nitrogen	0 84	0.34	0 49	0.63

Total nitrogen	100.0	59.7	59.1	71.8
Albuminoid nitrogen	61.1	44.0	36.6	42.6
Non-albuminoid nitrogen	38.9	15.7	22.5	29.2

Total nitrogen	100.0	59.7	59.1	71.8
Albuminoid nitrogen	100.0	72.0	60.0	70.0
Non-albuminoid nitrogen	100.0	40.5	58.3	75.0

B) Stem bark.

	April 28.	May 29.	December 3.
Moisture	69.4	65.6	52.3
Dry matter	30.6	34.4	47.7

In 100 parts of dry matter,

Crude proteids	18.3	10.2	12.9
Crude fats	5.5	5.3	6.2
Crude fibres	36.3	28.6	29.1
Total carbohydrates	—	—	17.9
Crude ash	7.5	6.3	6.0
Nitrogen-free extracts	35.6	49.6	45.8
Total nitrogen	2.77	1.63	2.07
Albuminoid nitrogen	2.09	1.10	1.48
Non-albuminoid nitrogen	0.68	0.53	0.59

Total nitrogen	100.0	58.8	74.7
Albuminoid nitrogen	75.5	40.0	53.4
Non-albuminoid nitrogen	24.5	18.8	21.3

Total nitrogen	100.0	58.8	74.7
Albuminoid nitrogen	100.0	52.6	70.8
Non-albuminoid nitrogen	100.0	78.0	86.9

The above tables clearly show that the reserve materials in the roots and stems undergo a very remarkable change during the development of leaves in spring. The greater part is transported to the growing parts, especially to the leaves, and there used partly for the formation of new cells and partly for the respiration process. Thus we see that in summer, when the leaves are in full growth, the roots and stems contain only very little reserve materials, but in autumn, the assimilation products formed in the leaves, again come down to the stems and roots and are there stored up to provide for future growth. Such a process is quite natural and every plant follows the same course; still there obtains a great difference in different plants, as to the quantity of the reserve materials and the rapidity of their migration. Some plants store up large quantities, while others contain very little. These differences must naturally exist not only among plants of different species, but also among different plants of the same species.

The reserve materials in plants are generally fats, carbohydrates and nitrogen compounds, but in the case of the mulberry, fats seem to play no important rôle.

It is a remarkable fact that non-albuminous nitrogen compounds (most probably amido-compounds) are contained as reserve materials in large quantities, corresponding, as they do, to nearly one-half of the total nitrogen.

As amido-compounds are soluble in water and easily transportable they may be conveniently used during the energetic development of the plant. Here we must not forget that, not the whole of the nitrogen compounds contained in the stems and roots, serves as reserve materials, but only some portions of them are capable of transformation; since there is a not inconsiderable quantity of nitrogen in the form of insoluble compounds.

The greater part of the reserve carbohydrates in the mulberry consists of starch, the presence of which may be easily demonstrated under the microscope. Further, we can easily prove the migration of starch during development without the aid of quantitative analysis. Thus, if we examine the bark of stems or roots under the microscope, we shall soon discover that in winter and in early spring, the bark is remarkably rich in starch grains, which, on the application of iodine, cover the entire field with violet spots. But in summer, when the leaves are fully

developed, we can hardly find a single starch grain under the same treatment.

The importance of reserve materials in the first stages of development is self-evident, and hardly needs an explanation, since the youngest buds can only develop by the aid of reserve materials, and even the green leaves, in their youngest stages, have very little assimilative faculty and must chiefly rely upon reserve materials until they become tolerably large. No plants can develop their leaves without the aid of reserve materials. But the precise extent to which the mulberry stands in need of reserve materials for proper development, is still open to question and must be discussed fully. There is no doubt that different plants needs different quantities of reserve materials, and if a plant contains a large quantity of reserve materials, it shows that the plant wants so much until it becomes able to assimilate the necessary nutriments from outside. Otherwise the plant would never keep in store an unnecessarily large amount of reserve materials.

As already shown in the preceding tables, a considerable amount of reserve materials is stored up in the stems and roots of the mulberry, the greater part of which is consumed during the development of the leaves; hence there is no doubt that this plant has need of a large amount of reserve materials, and it may naturally be expected that when the reserve materials are insufficient, the plant can not attain normal development. It is an evident fact that an enormous quantity of reserve materials moves toward the growing points of the buds and roots to build up new cells, and a still larger quantity of fats and carbohydrates must be consumed there by the energetic respiration which commences long before the new leaves are unfolded. The necessity of reserve materials will be the greater the quicker the development of young leaves, and the nutriments absorbed by the roots must be insufficient to meet the demand, as the absorptive power of the roots depends greatly upon the intensity of transpiration; and it may naturally be expected that in the first stages of development, when the leaves are very small the absorption of the nutriments must be very slow and thus makes the necessity of reserve materials still more urgent.

According to some recent investigations, proteids can be formed from amido-compounds or other inorganic nitrogen com-

pounds (ammonium salts or nitrates) in the absence of light, although much more slowly than in full day-light; the amido-compounds seeming, when the light is insufficient, to be far more conveniently used than the nitrates for the synthesis of proteids.

It is therefore very probable that the amido-compounds, which are present in the stems and roots of the mulberry, are far more efficiently and quickly used for the formation of new proteids in the growing roots and in the buds where light has no access, and can never be replaced by the inorganic nitrogen compounds absorbed from the soil.

As can be seen from the tables, the root-bark of Takasuke and that of Tsuruta and Jūmonji contained on May 18 and 29 respectively (the dates of cutting) only very little reserve materials. The new shoots are therefore compelled to commence their development with a very scanty source of reserve materials, so that it may sometimes happen that the reserve materials become exhausted before the new leaves can duly perform their function. The natural result in such a case would be an imperfect development of the leaves, as a consequence of which the assimilation process would be retarded and the nourishment of the new roots become insufficient and their development be more and more retarded until at last they would be compelled to die off, and the consequent deficient absorption of nutriments from the soil would react injuriously on the leaves. This may be compared to babies deprived of milk and nourished only with solid food, before the digestive organs have developed their powers. Only those plants which have effected a certain degree of development before the exhaution of reserve materials can attain normal growth.

We can now clearly understand why the variety Jūmonji, which requires the least amount of reserve materials as compared with the other varieties, is so rarely subject to the disease.

The following calculations will bring out this point more clearly;—

A) Takasuke, on April 28, had already developed new leaves, the fresh weight of which was 282 grams and the dry weight 48.2 grams for one stock, the nitrogen amounting to about 3.072 grams. This nitrogen must have come almost entirely from reserve materials in the stems and roots and not from the soil. Notwithstanding so much con-

sumption of reserve nitrogen for the development of new leaves, not an inconsiderable amount of nitrogen was, still afterwards, transported from the stems and roots to the leaves. That is to say, on April 28, the bark of the roots still contained 2.56% and that of the stems 2.74% of nitrogen; this, however, gradually decreased, and on May 18, we found only 1.73% in the bark of the roots and 1.91% in that of the stems. As the dry matter of the bark of the roots was nearly 250 grams and that of the stems 140 grams, we can calculate the total amount of the nitrogen transported after April 28; thus:—

$250 \times (2.56 - 1.73) = 250 \times 0.83\% = 2.075$ grams.....
transported from the roots

$140 \times (2.74 - 1.91) = 140 \times 0.83\% = 1.162$ grams.....
transported from the stems.

Sum total = **3.237** grams.

If now we add the nitrogen consumed before April 28, then we have:—

3.237 + 3.072 = **6.31** grams nitrogen, transported during the development of the leaves, of which nearly **4.15** grams was in the roots.

B) Tsuruta.

On April 28, new leaves contained already	2.79 gram.
After the 28th. transported from the roots	2.34
,, ,, ,, from the stems	0.52
Sum total	**5.65** grams nitrogen

Nearly 4.26 grams therefore was in the roots.

C) Jūmonji.

On April 28, the new leaves contained..	1.45 grams.
After the 28th. transported from the roots	1.50
,, ,, ,, from the stems	1.00
Sum total.....	**3.95** grams nitrogen.

Of this nearly 2.60 grams was in the roots.

The following table shows the decreased percentage of nitrogen in the dry matter.

		Takasuke.	Tsuruta.	Jumonji.
Total nitrogen	in the bark of roots	1.65%	1.42	0.87
	„ stems	1.65	1.16	1.14
Albuminoid nitrogen	„ roots	0.70	0.61	0.37
	„ stems	0.78	0.85	0.99
Non-albuminoid nitrogen	„ roots	0.95	0.81	0.50
	„ stems	0.84	0.31	0.15

Let us now try to see how much nitrogen was contained in the leaves and the new stems on May 18 and 28 respectively, viz. at the time of the full development of leaves.

	Takasuke (May 18.)	Turuta (May 28.)	Jumonji (May 28.)
Nitrogen in the new stems	1.330 g	1.782 g	1.150 g
„ „ „ leaves	13.340 „	16.210 „	12.640 „
Sum total.....	**14.670** „	**17.992** „	**13.790** „

The quantity of nitrogen transported from the roots and stems to the leaves is :—

Takasuke.	Tsuruta.	Jumonji.
6.31 g.	**5.65** g.	**3.95** g.

That is to say, Takasuke consumed 6.31 grams of reserve nitrogen to develop the new stems and leaves containing **14.670** grams nitrogen.

Therefore $\frac{6.310}{14.670}=43\%$ of the nitrogen in the new stems and leaves came from the reserve materials.

In Tsuruta $\frac{5.65}{17.992}=31\%$

In Jūmonji. $\frac{3.950}{13.790}=29\%$

It is surprising to find that the mulberry consumes a far greater quantity of reserve nitrogen than we supposed. We observe at the same time that Takasuke consumes a far greater quantity of reserve nitrogen than Tsuruta or Jumonji. This is especially interesting, since Takasuke is more liable to suffer from the disease than the other two varieties.

Of course, the above mentioned figures represent only approximate values, because there are individual differences among the same varieties, and absolutely exact comparisons are impossible. Further, the reserve nitrogen does not only migrate into the leaves, but a portion of it must, of course, be consumed in the roots. Nevertheless, the above is sufficient to show how important a part the reserve materials play during the development of new leaves in the mulberry.

We shall now turn our attention to the question, whether the new shoots that come out from the stump after cutting can be sufficiently nourished with the reserve materials remaining in the bark of the roots.

At the period of cutting, the bark of the roots contained the following quantities of nitrogen :—

	Takasuke (May 18.)	Tsuruta (May 28.)	Jūmonji. (May 28.)
Total nitrogen.....	1.73%	1.37	1.29
Albuminoid nitrogen	1.12	0.95	0.95
Non-albuminoid nitrogen	0.61	0.42	0.34

Absolute quantities in the root-bark of one stock.

	Takasuke. (May 18.)	Tsuruta. (May 28.)	Jumonji. (May 28.)
Dry matter in the bark of roots...	341 grams	293	38.2
Total nitrogen.....	5.900	4.020	4.930
Albuminoid nitrogen	3.820	2.780	3.630
Non-albuminoid nitrogen	**2.080**	**1.240**	**1.300**

Although the above are only approximate values yet there will be no great error in assuming that nearly 4–6 grams nitrogen is still contained in the roots after cutting; but this quantity of nitrogen is not entirely available for the young shoots, because a portion of it is in the form of insoluble compounds, and only a portion is capable of being transported to the growing parts. If we assume the quantity of non-albuminoid nitrogen as representing the quantity of available nitrogen, there will be no great error; and in that case 1.3–2.0 grams or at most 3 grams can be utilized by the new developing shoots. Let us now see whether this quantity is sufficient for the energetic development of the new shoots.

On July 11, when the new shoots had reached the height of 40–60 cm., they were analyzed, and the following results were obtained:

	Total dry matter.	Nitrogen in same.	Sum total of nitrogen.
1) Takasuke.			
New stems.....	19.6	0.337	3.262 g.
Leaves.	55.4	2.925	
2) Tsuruta.			
New stems.....	50.4	0.842	5.66 g.
Leaves.....	92.1	4.817	
3) Jūmonji.			
New stems.	28.4	0.585	3.20 g.
Leaves.....	50.0	2.620	

We see now that when the young shoots had reached the height of about 50 cm and the dry matter of the leaves amounted to about 50 grams, there were more than 3 grams of nitrogen

in the latter. The reserve nitrogen is therefore hardly sufficient for the normal development of the shoots, and some plants may suffer in consequence and become diseased.

One may ask now, how can we explain the fact that some varieties, like Takasuke, become diseased more easily than others, like Jūmonji. This I shall explain fully in the following pages.

As we see from the results of the analyses, the decrease of nitrogen in the bark of the roots of Jūmonji during the growing period, is smaller than in Takasuke and Tsuruta, and the total quantity of reserve nitrogen is also far smaller in Jūmonji than in the other two. This means that Jūmonji needs a far smaller quantity of reserve nitrogen to build up the same quantity of leaves and new shoots. The roots of Jūmonji seem to be especially fitted for the absorption of soil nutriments, and to make good the deficiency of the reserve materials already present. If now we compare the nitrogen contents of the leaves in the three varieties we find :

	Takasuke.	Tsuruta.	Jūmonji.
April 28,	6.40	6.80	5.76
May 18,	5.00	4.30	4.00

From this it is clear that Jūmonji can build up the same quantity of leaves with a far smaller quantity of nitrogen, that is, the necessity for nitrogen must be far smaller than in the other two varieties. Further, we have calculated that Takasuke consumes 6.31 grams reserve nitrogen to produce 1220 grams fresh leaves (=266.8 grams dry matter, containing 13.34 grams nitrogen), while in Jūmonji only 3.95 grams reserve nitrogen is spent to produce the same amount of fresh leaves (=316 grams dry matter, containing 12.64 grams nitrogen). Thus we see that Jūmonji needs only 62% or nearly $\frac{2}{3}$ of the reserve nitrogen required by the other two varieties to produce the same quantity of leaves. This evidently shows that Jūmonji has a stronger absorptive power for the nitrogen in the soil and manures, and does not rely upon reserve nitrogen so much as the other two. It is therefore not to be wondered at that, Jūmonji is less liable to attack by the disease, since the comparatively small quantity of reserve materials in the roots is soon made good by the newly absorbed nutriments.

But we must here remember that the power of resistance to the disease is not absolutely confined to certain fixed varieties, but may be gradually changed by climatic conditions, soil, and treatment. Thus we always observe that, when certain varieties are induced to rapid growth by the addition of soluble manures in excess, and then cut, then even the favored varieties may become diseased, while on the contrary, such varieties, as Takasuke, will never become diseased if they are cultivated in infertile soil with poor manuring. Thus, one and the same variety may undergo a very remarkable change in its character, especially as regards its conduct towards the disease. Overgrowth accelerates the migration of reserve materials. If the development of new shoots after cutting is very energetic, then the want for reserve materials must be correspondingly great, and the absorbed nutriments must be insufficient for the demand, the result being an emaciated condition of the shoots. Over manuring will never directly increase the quantity of reserve materials in the roots and stems in the growing periods, the nutriments supplied as manures being all transported to the growing parts. So if we cut such over-grown plants, the new shoots will develop more energetically and the reserve materials will soon be exhausted, just the natural condition for the disease. Thus we can understand why the power of resistance to the disease is not absolutely confined to certain fixed varieties. Young plants are rarely attacked; this may be explained by the fact that the cells of young plants are more active, and after cutting can develop small rootlets more easily, and thus gain a stronger absorptive power, than old plants, so that they can easily recover from the deficiency of reserve materials.

Old plants are less active, and after cutting, the development of new rootlets takes place with more difficulty, and accordingly, their absorptive power must remain comparatively stationary and the recovery will consequently be slower.

For the same reason, the disease appears oftener after cutting in late summer or autumn, while it is less frequent when the plants are cut earlier. The development of new rootlets and the consequent recovery after cutting, must be much more difficult in autumn.

The young rootlets must once lose their activity after cutting, and the entire root-system will become gradually ineffici-

ent, unless the development of the new rootlets is exceptionally good; and after successive cuttings, the small roots must entirely die off. So it is quite natural that we always find decayed roots when the disease is much advanced. But in the earlier stages of the disease, we find only small rootlets dead. The roots and leaves are closely correlated to each other, a bad condition in the one accelerating the degeneration of the other; and the primary cause of the disease must be sought in the practice of cutting in the growing period.

We see [Plates XIX–XXVI] that the quantity of reserve nitrogen in the roots of Takasuke, Tsuruta etc. is not restored to its norm even in December. This evidently shows a gradual wearing of the plants, and after two or three years, they must become diseased unless they are kept from cutting.

In the foregoing pages, we have considered only the nitrogen compounds; but we must remember that the carbohydrates, especially starch, have also the same physiological importance during the first stages of development That the cutting in the growing period, when the starch contents of the roots have reached the minimum, has a specially injurious effect upon the new shoots hardly requires any further explanation.

The view above developed finds an additional support from the following facts:—

(1). The disease does not affect those plants which are not cut. This is true throughout the whole country and there is no exception to it. We have observed this in such provinces as Fukushima, Yamagata, Akita, Hyogo, etc., where the cutting method is not practiced. The plants in these provinces attain their maximum height and are 30–40 years, or sometimes even more than 100 years old. Further, we have observed a very instructive case in these provinces, viz. some of the farmers adopted the method of cutting, and all suffered from the disease, while in the neighbouring farms where the method was not adopted the plants were perfectly healthy. A more striking fact was observed in Tanba. A farmer cut the same plants 3 times in one ummer, in consequence of which, all the plants in a farm without exception became diseased, while in the neighbouring farm in which the plants were cut only once, the disease did not appear. That the cutting is the principal cause of the disease may also be shown by the fact that, by keeping the diseased plants for

several years from cutting, most of them can be made to recuperate.

Many experiments have been made to prove this fact. Thus we see :—

Variety.	Date of cutting.	Number of cutting.	Number of plants used for experiments.	Result. Became partly diseased.	Diseased.	Remained healthy.	Death.
Nezumi-gayeshi	July 5.	1	10	4	1	5	—
Jumonji	„	1	5	1	1	3	—
Obata	„	1	5	1	2	2	—
Hikojiro	„	1	5	1	1	3	—
Tsuruta	„	1	5	1	3	1	—
Takowase	„	1	5	—	4	1	—
Hosoye	August 19.	1	50	6	9	23	12
„	Late autumn (once cut before budding in spring.)	2	25	5	10	10	—
„	„	2	15	5	4	5	1
„	August 26.	1	30	3	13	6	8
Yotsume	„ 28.	1	30	4	6	16	4
Hosoye	„ 26.	1	15	4	6	3	2
„	„ 23.	1	15	—	12	3	—
Total			**215**	**35**	**72**	**81**	**27**
Ratio			**100**	**16**	**34**	**38**	**12**

The disease did not appear in the control (not cut) plants. A similar result has been reported by Mr. Ichikawa. Though he does not mention the age of the experimented plants, yet I do not doubt that they were moderately old ; young plants do not show, in my opinion, such a remarkable effect.

We have also made a similar experiment in 1898 with the variety Nezumigayeshi, eight years old :—

Date of cutting.	Number of cutting.	Number of plants.	Healthy.	Partly diseased.	Diseased.
May 16.	1	28	26	—	2
„	1	11	11	—	—
„	1	11	11	—	—
June 1	1	20	20	—	—
„	1	11	11	—	—
„	1	11	11	—	—
„ 20	1	20	14	—	6
„	1	11	9	—	2

The same experiment was repeated in 1899 with the same variety in the same farm :—

Date of cutting.	Number of cuttings.	Number of plants.	Healthy.	Diseased.
June 1	1	20	16	4
June 20	1	20	13	7
„	1	11	3	8
Total		51	32	19
Percentage		100	63	37

The control plants all remained healthy.

Hence it is quite evident that the cutting is the principal cause of the disease.

(II). If my assumption be true, then the disease must be induced in healthy plants by simply picking off the leaves after their full expansion, as by this means the reserve materials in the roots and stems must as well become exhausted. Following is the result of such an experiment.

Plot.	Variety.	Number of plants.	Date of picking off the leaves.	Result.
All the leaves taken.	Komaki.	5	3 times. (May 7-Sept 9)	Healthy 3 Diseased 2
A portion of leaves taken.	Komaki	5	3 times. (Apr. 28-Sept. 9)	Healthy 5 Diseased 0
New stems, together with leaves taken.	Rosō, Tsuruta, Takasuke.	980	2 times. (May 18-July 15)	Healthy 995 Partly diseased 96 Diseased 198
,,	Takasuke.	6	1 times. (May 28)	Healthy 5 Diseased 1
Stem cut off.	Takasuke, Hosoye, Akagi.	122	1 times. (May 21)	Healthy 75 Diseased 34 Dead 13
Total.		1118		Healthy **783** Diseased **322**

This table shows that by frequent picking off of the leaves, nearly $\frac{1}{3}$ of the plants may become diseased.

Second Experiment.

Variety.		Date of picking.	Number of plants.	Healthy.	Diseased.	Partly diseased.	Dead.
Takasuke,	All the leaves taken.	August 14	92	81	2	9	—
,,	A portion of leaves taken.	,, 17	82	68	2	12	—
,,	All the leaves taken.	July 14 ,, 30 August 15 ,, 30 Sept. 13	84	69	1	14	—
Rosō.	A portion of leaves taken.	August 20 ,, 30 Sept. 8 ,, 15 ,, 23	561	530	6	20	2

Third experiment.

Plot.	Variety.	Date of picking.	Number of plants.	Healthy.	Diseased.
A portion of the leaves on new shoots taken.	Nezumi-gayeshi.	August 16	35	32	8
All the leaves on new shoots taken	,,	June 1.	40	28	12
A portion of the leaves taken 3 times.	,,	June 1. June 10. Sept. 20.	40	37	8
All the leaves taken 3 times	,,	June 1. July 10. Sept. 20.	40	31	9

Fourth experiment.

Plot.	Variety.	Date of picking.	Number of plants.	Healthy.	Diseased.	Dead.
A portion of leaves on new shoots taken.	Nezumi-gayeshi		35	28	5	2
A portion of new shoots picked.	,,		40	25	15	—
New shoots wholly cut.	,,		40	16	24	—
A portion of leaves picked 3 times.	,,	May 28. July 10. Sept. 20.	40	35	5	—
All the leaves picked 3 times.	,,	May 28. July 10. Sept. 20.	40	20	20	—

No case of the disease was found in the control plants, which were not deprived of their leaves. See Plates XXXV–XXXVI.

The age of the plants, varietal peculiarities and other conditions have a great influence upon the disease.

It is a well known fact that in those provinces where silkworm culture was recently introduced, the disease is especially prevalent, because in these provinces, the farmers try to get the largest possible crop of the leaves from rather small farms, and consequently, over-manuring and frequent picking of the leaves, sometimes followed by cutting, is commonly practiced. Further, those varieties such as Takasuke, Hosoye, etc., which grow rather rapidly, are mostly preferred. Moreover, silkworm culture in late summer or autumn is especially injurious for the mulberry, since the leaves are taken off in autumn, and the assimilation products in them to be utilized by the stems and roots for the next year's growth, are neccessarily lost ; and thus the principal cause of the wearing of the plants is brought about.

One might suppose that by giving an excess of soluble manures, the injurious effect of the frequent picking of the leaves or of cutting, can be counterbalanced ; such a view is erroneous. In the growing period, manuring does not directly nourish the stems or roots ; the nutriments being all transported to the growing parts, especially to the leaves ; and in late autumn, the assimilation products in the leaves come down again to the roots and stems and are stored there until the next spring. In the growing period, the roots and stems merely serve as a passage for the nutriments. Therefore if we cut off these over-grown plants in the growing season, the new shoots will grow energetically and the reserve materials must be rapidly exhausted, the disease being the result.

Here I shall cite one more example showing that the disease is nothing but the result of the deficiency of the reserve materials. Healthy and diseased plants in the same farm were cut on August 30, and the new shoots coming from the diseased stems showed distinct signs of the disease even in the earliest stage. On October 15, the plants were cut down and analyzed, with the following result :—

	Leaves.			Stems.		
	Healthy.	Diseased.	Ratio.	Healthy.	Diseased.	Ratio.
Moisture.	78.90	73.64	100 : 93.0	87.35	85.05	100 : 97.3
Dry matter.	21.10	26.36	100 : 125.0	12.65	14.95	100 : 118.0

In 100 parts of dry matter,

Ash.	11.76	7.82	100 : 66.5	12.5	8.90	100 : 71.2
Total nitrogen.	5.28	3.70	100 : 70.0	3.16	3.29	100 : 104.1
Albuminoid nitrogen.	3.80	2.70	100 : 71.0	1.40	1.39	100 : 92.9
Non-albuminoid nitrogen.	1.48	1.00	100 : 67.9	1.76	1.99	100 : 113.0

We see from this that the new shoots coming from the diseased stocks are considerably poorer in nitrogen and ash, which evidently shows that their roots contained very little reserve materials, which were insufficient to meet the demand of the new shoots even in the first stages of development.

(III). By grafting diseased shoots on healthy roots or stems, many of them can be made to recover and grow normally. We may therefore infer that the disease is exclusively due to deficiency of nutriments, and may be prevented by replacing worn-out roots with vigorous ones. The following experiments prove this point.

First experiment.

Plot.	Variety.	Number of experiments.	Positive results.	Negative result.	Positive but diseased.
Diseased roots of to Healthy stems of	Takowase / Nezumigayeshi	20	0	18	2
Diseased stems of on Healthy roots of	Hosoye / Rosō	20	6	13	1

Second experiment.

Plot.	Variety.	Number of experiment.	Positive result.
Diseased stems of ..... to healthy stems of	Takowase / Nezumigayeshi	30.	8
,, ...	,,	,,	21
Diseased stems ..... to healthy root.....	,,	,,	8
		,,	12
Diseased stems ..... to healthy *Misho*.....	,,	,,	10
	,,	,,	15
Diseased stems ..... on diseased roots.....	,,	,,	0
Healthy stems ..... Diseased roots or stems	,,	,,	0

In the control experiments (grafting of healthy shoots on healthy roots) nearly 60% were successful.

(IV). By layering i,e. burying a portion of the diseased shoots bent into the earth, as shown in Pl. XXXVII–XXXIII. The new rootlets are produced from the covered part, and absorb nutriments from the soil, and the shoots recover from the disease. Numerous experiments have shown this fact, and even the severet cases of the disease may sometimes be suecessfully treated in this way. See Plates XXXVIII–XXXVIII.

(V). By keeping diseased plants from cutting for two or three years and well manuring, many can be made to recover, as has been proved by many experiments. But if these plants are again cut in the growing season they will become again diseased. Further, if we cut down the diseased shoots in early spring before the leaves are developed, the next new shoots will grow normally. This may be explained by considering that the roots of diseased plants may still contain a moderately large quantity of reserve materials during the winter, if they were kept from cutting; so that the new shoots may develop normally without suffering from the deficiency of reserve materials. In the experiment made in 1898, in which 22 diseased plants were kept from cutting, 11 plants recovered and 3 more showed signs of imperfect recovery. In another experiment made in the same year 15 recovered out of 22, while those that were subjected to cutting in the growing season, did not only not recover, but became even more severely diseased. The result obtained in 1899 is equally interesting, 13 plants having recovered out of 22 diseased plants; while in the case of plants subjected to cutting none recovered.

(VI). After cutting in the growing season, a considerable amount of the sap flows out from the cut stems for several days, amounting sometimes to several hundred cubic centimenters for one plant. And as this sap has been believed by many to have an intimate relation to the exhaustion of the reserve materials, I have directed my attention to its chemical analysis. For collecting the flowing sap India rubber tubes were connected at one end with the cut stems and at the other with tightly corked test tubes.

a). Sap of Obata. Collected on May 20.

Colour.—Slightly turbid; after standing for several hours, a little precipitate was formed at the bottom.

Reaction.—Faintly acid.

Specific gravity.—1.001.

Qualitative tests :—

1. Nitrates.—Diphenylamine reaction, dark blue colouration :—

   Nitrates present in tolerable quantity.

2. Ammonia.—Nessler's reagent produced brown precipitate. The solution boiled with a little caustic potash, ammonia gas evolved, which turned red litmus paper distinctly blue and yellow turmeric paper brown. Doubtful whether the ammonia was present as such in the original fresh solution or was derived from the decomposition of proteids or amido-compounds. Normal sap commonly contains no ammonia. Further, a brown precipitate may also be produced by Nessler's reagent in the presence of sugars.

3. Lime salts.—A little present, white precipitate by ammonium oxalate.

4. Sulphate.—Doubtful trace.

5. Chlorides.—Tolerably much, white precipitate by silver nitrate.

6. Iron salts.—Absent.

7. Proteids.—Biuret reaction, only faintly violet.

   No precipitate by nitric acid.

   Almost no precipitate by potassium ferrocyanide and acetic acid.

   From these reactions, the presence of proteids is doubtful, or it must have been decomposed during the collecting of the sap.

8. Sugars.—Slightly reduces Fehling's solution.

100 c.c. of the sap yielded 0.0172 grams nitrogen.

b). Sap of Jūmonji. June 2.

Colour.—Same as in Obata.

Specific graviiy.—1.0007.

100 c.c. contained.—0.007 grams nitrogen.

0.185 grams dry matter.

0.080 grams ash (76% of which dissolves in hydrochloric acid.)

0.095 grams organic matter.

The sap of Jūmonji contained far less nitrogen than that of Obata. The composition of the sap may therefore be very different according to varieties, time of gathering and other conditions. The nitrogen contained in the sap may come partly from the reserve materials in the roots and partly from the freshly absorbed nutriments. I have not determined the exact quantity of the sap that flows out from one plant, as it is rather difficult. But it is plain enough that Takasuke and Tsuruta furnish a far greater quantity of it than Jūmonji, which fact may have some significance for the resisting capacity of these varieties towards the disease, though I do not believe it has so much influence upon the disease as many suppose.

The numerous facts above mentioned are in full accord with my view.

I must here add a few words on a case that I have observed very often, viz. that the cut ends of the stems decay and the putrefaction preceeds between the wood and the bark towards the inner part, and interrupts the connection between the vascular bundles of the old stems and those of the new shoots, and thus prevents a free circulation of the nutriments into the growing shoots. For a time I thought that this putrefaction was the

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Sometimes the disease appears on plants which have never been cut, or on young plants which has not yet attained the age of cutting; but these cases are very rare and may have some special cause, either attack of fungi or insects, etc., or some physiological abnormality. I have analyzed a young plant which has never been cut, but some leaves of which showed signs of the disease, and obtained the following results:—

	Leaves.		Stems.	
	Healthy.	Diseased.	Healthy.	Diseased.
Total nitrogen	3.42	3.04	2.15	2.00
Albuminoid nitrogen	2.94	2.37	1.50	1.53
Non-albuminoid nitrogen	0.48	0.67	0.65	0.47
Ash	10.7	8.6	6.0	6.1

	Leaves.		Stems.	
	Healthy.	Diseased.	Healthy.	Diseased.
Total nitrogen	100.0	88.8	100.0	93.2
Albuminoid nitrogen	„	80.6	„	102.2
Non-albuminoid nitrogen	„	140.4	„	72.3
Ash	„	80.4	„	101.0

Thus we see that the diseased leaves and stems are considerably poorer in nitrogen. So we may conclude that the disease appears when the nitrogen supply is reduced beyond a certain limit, whatever the efficient cause may be.

cause of the disease. But as my observation became more extensive, I found that in many diseased plants there was no putrefaction, and also that it was not generally observed in the first stage of the disease. So it is very probable that this putrefaction is only a secondary phenomenon accopanying the disease and not its primary cause. Nevertheless the putrefaction unavoidably accelerates the disease and hastens the death of the whole plant. Further, the sap flowing out from the cut stems may be a good nourishment for small orgamsms. As the sap is very abundant in Takasuke, Tsuruta etc, it is natural that these varieties are especially prone to putrefaction.

Again many believe that the principal cause of the disease lies in the decay of the roots. It is true that the roots of the diseased plants are generally in a very bad condition, the small roots having almost entirely decayed; but at the beginning of the disease, the roots are generally quite normal. Moreover, if the decay of the roots be the cause of the disease we could not understand why those plants which are not subjected to cutting are entirely free from the disease.

It is very interesting to see whether other plants are also liable to the same disease when subjected to repeated cutting or when frequently robbed of their leaves in the growing season. Japanese Salix is cultivated in Tanba and Tango just in the same manner as the mulberry, but the stems are cut in late autumn when the leaves have fallen down. This is a very rational mode of precedure and entirely in harmony with the teachings of plant physiology, and we have never observed the disease in this plants.

Japanese tea plant is generally subjected to frequent picking of the leaves, sometimes even 3 or 4 times in a year, and we observe very often that in such a case the leaves become smaller and can not develop well, and that sometimes even the whole plant dies; but the disease is soon healed by good manuring.

Summary and Conclusions.

1). The diseased leaves are remarkably poor in nitrogen and the development of fibres is considerably retarded ; no other peculiarity is regularly found. The shrinking of the leaves and the retardation of growth may be due to the deficiency of nitrogen and the bad development of fibres.

The deficiency of nitrogen in the diseased plants is not caused by an insufficient supply of nitrogen manures in the soil, but must be due to a diminution of the absorptive power of the roots, and also of chemical activity in the plant cells ; since the disease is always observed in those places where soluble manure is given in excess and over-growth is induced. Further, the diseased plants can never recover on simple application of nitrogen manures.

The diminution of chemical activty in the living cells, owing to the deficiency of nitrogen, may also be the cause of the bad development of fibres, since the formation of cellulose from soluble carbohydrates is performed by the living protoplasm.

2). During winter a considerable amount of reserve materials (especially nitrogen compounds and starch) is stored up in the bark of stems and roots, and in spring, when the development of new leaves commences, the greater part is transported to the growing parts, and the assimilation products in the leaves again come down in late autumn, when the leaves begin to fall. Therefore the stems and roots are considerably poorer in reserve materials during the growing season. Now it will be at once evident that the cutting of the plants in the growing season must have a very bad effect on the new developing shoots, since they must be nourished with scanty reserve materials, and moreover, it is not impossible that the reserve materials may be entirely exhausted before the new shoots have attained a certain height and become able to assimilate independently enough nutriments from outside. In such a case the shoots will not grow normally and the disease must be the result. Many facts support this view :—

a). The first appearance of the disease is always in the new shoots, after cutting in the growing season.

b). The disease is not observed where the plants are not cut, and even plants already diseased may recover when kept from cutting for some years.

c). Many experiments show that cutting in the growing season is followed by the disease, while it is not observed when the plants are left without cutting.

d). The disease is not induced when the stems are cut during winter or in early spring before the leaves are unfolded.

3. Not only by cutting in the growing season, but also by frequent picking of the leaves, the reserve materials in the roots and stems, may be exhausted, and the new leaves developed subsequently become diseased, as proved by many experiments.

4. Some varieties, such as Takasuke, store up a large quantity of reserve materials, while others, like Jūmonji, contain comparatively little. The former need a far greater amount of reserve materials during the devlopment of the leaves, while the latter require only a comparatively small amount. This indicates that Takasuke has a weaker absorptive power for soil nutriments in the first stages of development. So it must be very difficult for it to counterbalance the deficiency of reserve materials with the nutriments absorbed from the soil. The consequence is that Takasuke is more liable to the disease than Jūmonji. But such a propensity is not absolutely confined to certain varieties; on the contrary, it must have a wide range of variation even among the same variety and is subject to modicification by various conditions. Generally speaking, a plant becomes more liable to the disease by accelerating its growth with abundant soluble manures, and by some other treatment. Therefore no variety would be absolutely free from the disease if they were cut in the growing season, or if the leaves were picked frequently.

5. Young plants become very rarely diseased. This may be due to energetic development of the roots and a large capacity for the absorption of nutriments in the young plants; while old plants have less power of developing new roots, and consequ-

ently the deficiency of reserve materials can not be made good by the nutriments absorbed from outside. For the same reason, cutting in late autumn produces more cases of the disease than cutting in early summer. Since the activity of plant cells is already diminished in late autumn the development of new roots must be more difficult.

6. Micro-organisms are not the cause, because they are not always present in the diseased plants. Further, the decay of the roots of the diseased plants may be a secondary phenomenon, since we can not understand why the disease is not observed when the plants are left without cutting, or why the diseased plants may even recover by being kept from cutting, for some years. Shoots of the diseased plants may develop normally when they are grafted on healthy roots or stems, or when they are covered with earth and propagated by cutting. But there is no doubt that the mirco-organisms have some accelerating influence upon the disease and at last cause the death of the plants.

7. As regards the methods for the prevention and cure of the disease, we must leave them to future investigations, since we have not succeeded in finding any that promises success.

I. Comparison of healthy and diseased plants.

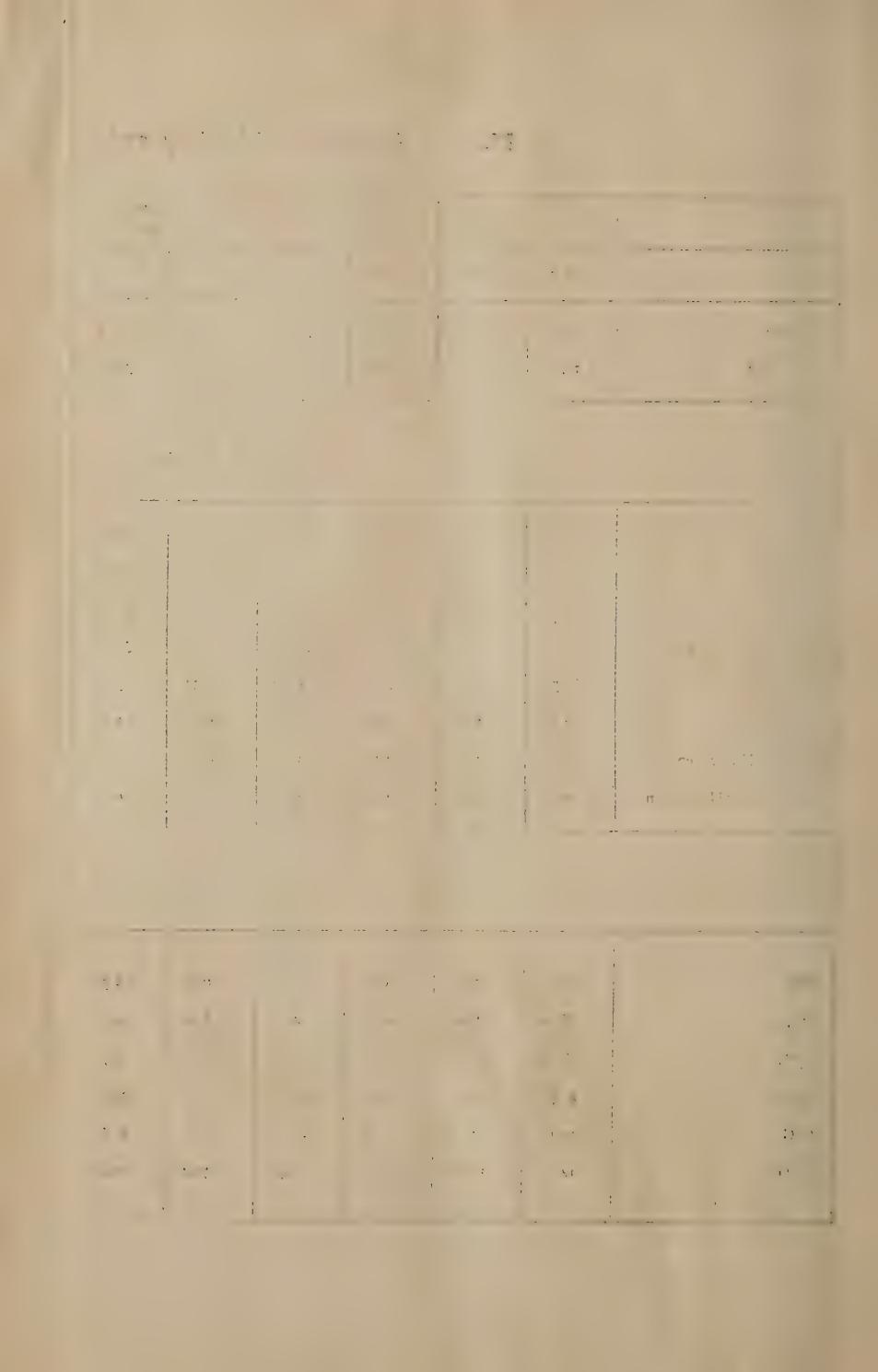
	Tsuruta (I) May 6.		Tsuruta (II) Oct. 15.		Hosoye (I) May 6.		Hosoye (II) Oct. 15.		Yotsume May 22.		Takasuke (I) May 22.		Takasuke (II) July 9.		Takasuke (III) Sept. 9.		Jumouji (I) July 9.		Jumouji (II) Sept. 9.		Average.		Ratio.	
	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased	Healthy.	Diseased.	Healthy	Diseased
Average length of shoots	96.1	45.0	—	—	195.0	82.5	39.0	33.0	66.0	45.0	90.00	45.00	30.0	18.0	180.0	90.0	16.50	12.00	150.0	75.0	95.80	49.5	**100.0**	**51.7**
Fresh weight of 1 shoot	59.7	15.1	—	—	205.0	18.85	2.22	0.904	29.3	6.00	50.0	78.70	5.45	1.04	101.0	36.3	2.50	1.02	58.5	12.00	57.07	11.10	**100.0**	**19.4**
Dry weight of 1 shoot	—	—	—	—	—	—	0.28	0.135	—	—	—	—	0.87	0.24	29.56	11.06	0.30	0.115	17.19	3.33	9.64	2.98	**100.0**	**31.0**
Misture in shoots	—	—	—	—	—	—	87.35	85.05	—	—	—	—	84.04	78.00	70.66	69.49	88.04	88.60	70.60	72.27	80.14	78.68	**100.0**	**98.2**
Dry matter in shoots	—	—	—	—	—	—	12.65	14.95	—	—	—	—	15.96	22.00	29.34	30.51	11.96	11.40	29.40	72.73	19.86	21.32	**100.0**	**107.3**
Number of leaves on 1 shoot	57.0	31.0	—	—	224.0	5.0	10.0	1.30	140.0	40.0	136.0	45.0	18.00	19.00	36.0	26 6	7.00	11.00	45.00	37.00	75.00	57.00	**100.0**	**76.0**
Dry matter in leaves of 1 shoot	2.36	0.42	—	—	5.37	0.52	0.695	0.422	7.15	0.77	15.09	2.02	1.622	0.647	31.02	20.34	0.82	0.28	18.42	4.75	9.17	3.35	**100.0**	**36.6**
Fresh weight of 1 leaf	0.229	0.065	3.22	0.36	0.111	0.049	0.304	0.126	0.181	0.072	0.376	0.141	0.39	0.11	2.57	0.16	0.982	0.249	1.18	0.35	0.954	0.168	**100.0**	**17.6**
Dry weight of 1 leaf	0.041	0.014	0.964	0.135	0.024	0.010	0.066	0.033	0.0513	0.0195	0.111	0.045	0.10	0.034	0.87	0.076	0.113	0.024	0.41	0.127	2.275	0.052	**100.0**	**18.8**
Moisture in leaves	81.20	78.14	70.00	62.60	79.84	78.81	78.90	73.64	71.63	72.60	70.50	68.00	76.70	69.15	66.23	52.70	88.50	90.0	65.24	63.12	74.87	70.88	**100.0**	**94.7**
Dry matter in leaves	18.80	21.86	30.00	37.40	20.16	21.19	21.10	26.36	28.37	27.40	29.50	32.00	23.30	60.85	33.77	47.30	11.50	10 0	34.76	36.88	25.13	29.12	**100.0**	**116.0**

II. Comparison of healthy and diseased plants (Leaves).

	Tsuruta (I) May 6.		Tsuruta (II) Oct. 15.		Hosoye (I) May 6.		Hosoye (II) Oct. 15.		Yotsume May 22.		Takasuke (I) May 22.		Takasuke (II) July 9.		Takasuke (III) Sept. 9.		Jûmonji (I) July 9.		Jûmonji (II) Sept. 9.		Average.		Ratio.	
	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	D'seased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased.	Healthy	Diseased.	Healthy.	Diseased.
Moisture	81.20	78.14	70.00	62.60	79.84	78.81	78.90	73.64	71.63	72.60	70.50	68.00	76.70	69.15	66.23	52.70	88.50	90.00	65.24	63.12	74.87	70.88	**100.0**	**94.7**
Dry matter	18.80	21.86	70.00	27.40	20.16	21.19	21.10	26.36	28.37	27.40	29.50	32.00	23.30	30.85	33.77	47.30	11.50	10.00	34.76	36.88	25.13	29.12	**100.0**	**116.0**
In 100 part of dry matter,																								
Crude proteids	47.94	34.56	26.88	23.13	41.00	38.00	33.00	23.13	28.75	27.94	23.75	18.44	30.50	23.13	22.88	20.25	36.63	32.50	22.38	16.50	31.47	25.76	**100.0**	**81.8**
Crude fats	1.92	3.10	5.80	4.40	2.26	1.51	5.19	4.96	3.83	3.45	3.46	3.34	2.84	3.05	7.34	4.34	4.26	3.08	7.29	6.72	4.42	3.80	**100.0**	**86.0**
Crude fibres	41.27	54.20	8.74	6.70	49.18	52.33	10.53	7.26	59.66	60.07	9.61	8.60	11.14	8.03	9.59	7.11	11.04	9.56	9.32	9.73	10.00	8.14	**100.0**	**81.4**
Nitrogen-free extracts			51.23	57.71			39.52	56.83			56.84	63.40	47.26	58.90	52.42	60.88	37.67	45.04	50.88	60.50	47.97	57.60	**100.0**	**120.0**
Ash	7.87	8.14	7.35	8.06	7.56	8.16	11.76	7.82	7.76	8.54	6.34	6.13	8.26	6.89	7.77	7.42	10.40	9.82	10.13	6.55	8.52	7.75	**100.0**	**91.0**
Total nitrogen	7.67	5.53	4.30	3.70	6.56	6.08	5.28	3.70	4.60	4.47	3.80	2.95	4.88	3.70	3.66	3.24	5.86	5.20	3.58	2.64	5.02	4.12	**100.0**	**81.3**
Albuminoid nitrogen	5.15	4.07	3.60	3.00	4.08	3.94	3.80	2.70	4.34	4.15	3.05	2.79	3.85	3.35	3.37	2.98	4.18	4.10	3.10	2.33	3.85	3.34	**100.0**	**86.6**
Non-albuminoid nitrogen	2.52	1.46	0.70	0.70	2.48	2.14	1.48	1.00	0.26	0.32	0.75	0.16	1.03	0.35	0.29	0.26	1.68	1.10	0.48	0.31	1.17	0.78	**100.0**	**66.6**
In 100 parts of pure ash																								
SiO_2	3.71	3.37	1.68	1.85	1.07	2.50	4.87	4.00	3.44	4.60	2.64	3.77	4.68	4.83	1.35	1.54	1.90	2.10	1.42	1.78	2.68	3.03	**100.0**	**113.1**
SO_3	6.23	3.86	2.32	2.64	5.15	4.27	3.25	3.66	3.26	3.34	3.64	4.00	2.60	2.81	1.22	1.90	2.43	2.70	1.70	1.70	3.18	3.09	**100.0**	**97.2**
P_2O_5	14.34	13.55	9.44	7.52	12.68	14.99	8.56	11.80	13.86	13.14	17.90	19.02	14.60	11.90	6.41	6.10	20.40	20.60	6.57	8.20	12.48	12.69	**100.0**	**101.6**
K_2O	35.20	30.53	27.40	14.10	36.30	32.00	24.35	23.20	31.81	28.30	28.51	29.43	21.15	18.70	19.20	18.10	23.63	24.66	23.92	26.50	27.15	25.05	**100.0**	**92.3**
CaO	15.20	18.9	22.10	38.60	17.23	15.75	27.80	30.00	25.07	23.08	23.64	23.02	27.21	32.43	40.28	35.54	28.10	26.77	39.67	36.87	26.63	28.09	**100.0**	**105.5**
MgO	8.22	10.46	9.60	12.20	8.45	7.26	8.50	7.00	11.48	11.60	10.44	12.82	10.13	14.42	13.78	18.65	8.85	12.56	12.05	15.55	10.15	12.25	**100.0**	**120.6**

III. Comprison of healthy and diseased plonts (Stems.)

	Takasuke (I) Oct. 15.		Takasuke (II) July 9.		Takasuke (III). Sept. 9.		Jumonji (I) July 9.		Jumonji (II). Sept. 9.		Average.		Ratio.	
	Healthy.	Diseased.	Healthy.	Diseased.	H althy.	Diseased.	Healthy.	Diseased.	Healthy.	Diseased	Healthy.	Diseased.	Healthy.	Diseased.
Moisture	87.35	85.05	84.04	78.00	70.66	69.49	88.04	88.60	70.60	72.27	80.14	78.68	100.0	98.2
Dry matter	12.65	14.95	15.96	22.00	29.34	30.51	11.96	11.40	29.40	27.73	19.86	21.32	100.0	107.3
In 100 parts of dry matter,														
Crude proteids	19.75	20.56	15.38	14 44	5.38	10.06	21.75	26.63	5.31	5.41	13.51	15.43	100.0	114.2
Crude fats	2.35	3.70	0.83	2.20	1.10	1.57	2.20	2.54	1.00	1.30	1.50	2.26	100.0	151.0
Crude fibres	65 40	66.84	46.30	40.10	54.60	50.54	36.72	27 67	59.00	56.20	49.16	43 64	100.0	88.8
Nitrogen-free extracts			31 54	36.93	34.58	32.56	31.85	31 52	30.36	33.10	32.08	33 55	100.0	104.6
Crude ash	12.50	8.90	5.95	6.29	4.34	5.27	7.48	11.64	4 33	3 87	6.92	7.19	100 0	103.9
Total nitrogen	3.16	3.29	2.46	2.31	0.86	1.61	3 48	4.26	0.85	0.87	2.16	2.47	100.0	114 2
Albuminoid nitrogen	1.40	1.30	1.10	1.20	0.54	0.98	1.47	1.79	0.57	0 66	1.02	1.19	100.0	117.0
Non-albuminoid nitrogen	1.76	1.99	1.36	1.11	0.32	0.63	2.01	2.47	0.28	0.21	1.14	1.28	100.0	112.3
In 100 parts of pure ash,														
SiO_2	1.02	1.90	1.19	2.90	0.94	1.36	—	—	1.40	2.31	1.14	2.12	100.0	186.0
SO_3	6.00	7.10	4.20	4.20	2.00	4.00	—	—	1.60	2.60	3.40	4.48	100.0	132.0
P_2O_5	8.10	10.90	14.64	18.87	8.90	8.72	—	—	7.80	9.75	9.86	12.07	100 0	123.0
K_2O	29.7	29.5	38.5	31.3	39.6	34.9	—	—	31.6	34.66	34 85	32.59	100.0	93.5
CaG	19.10	24.00	22.26	28.90	18.80	16.62	—	—	24.76	23.26	21.23	23 30	100.0	110.0
MgO	14.10	15.00	13.70	16.43	7.04	12.46	—	—	9.14	11.74	11.00	13.00	100.0	126.0



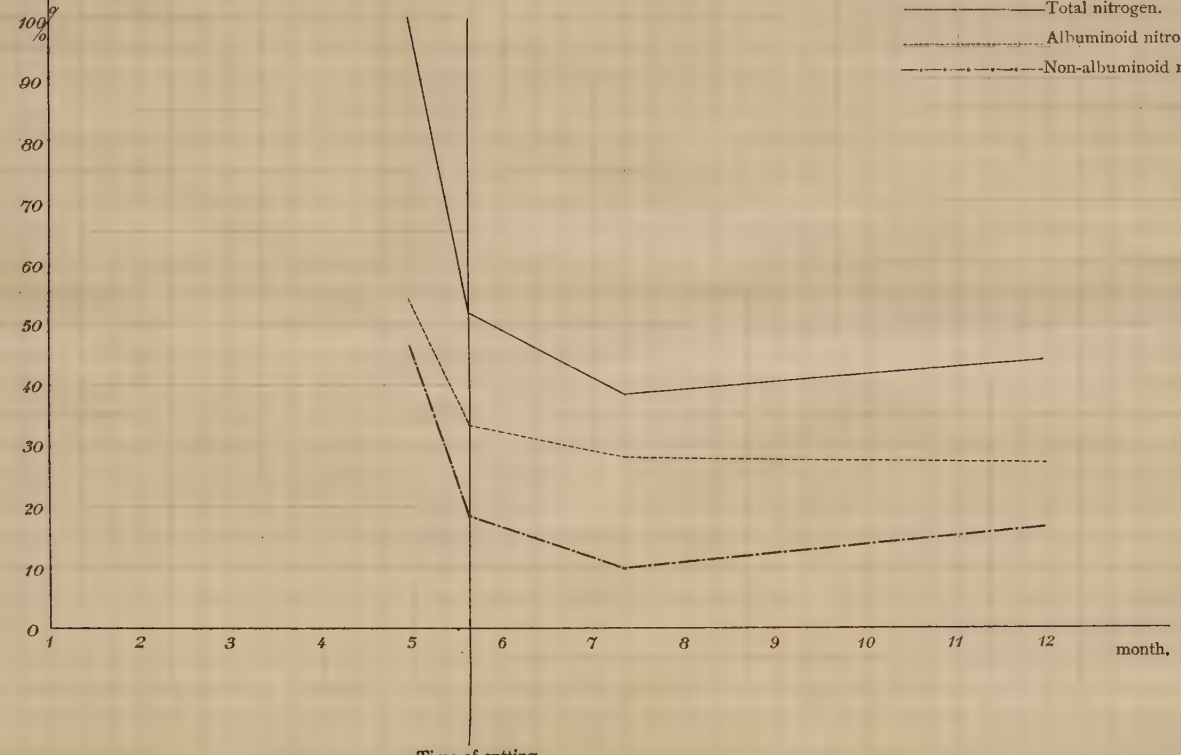
IV. Comprison of the chemical composition of different varieties (Healthy plants.)

	Leaves (May 6).		Leaves (May 22.)		Leaves (July 9.)		Stems (July 9.)		Leaves (Sept. 9.)		Stems (Sept. 9).	
	Tsuruta	Hosoye	Yotsume	Takasuke	Takasuke	Jūmonji	Takasuke	Jūmonji	Takasuke	Jūmonji	Takasuke	Jūmonji.
Average length of shoots							30.00	16.5			180.0	150.0
Fresh weight of 1 shoot							5.45	2.50			101.0	58.5
Dry weight of 1 shoot							0.87	0.30			29.56	17.19
Fresh weight of 1 leaf	0.229	0.111	0.181	0.376	0.39	0.982			2.57	1.18		
Dry weight of 1 leaf	0.041	0.024	0.051	0.121	0.10	0.113			0.87	0.41		
Moisture	81.20	79.84	71.63	70.50	76.70	88.50	84.04	88.04	66.23	65.24	70.66	70.60
Dry matter	18.80	20.16	28.37	29.50	23.30	11.50	15.96	11.96	33.77	34.76	29.34	29.34
In 100 parts of dry matter,												
Crude proteids	48.94	41.00	28.75	23.75	30.50	36.63	15.38	21.75	22.88	22.38	5.38	5.31
Crude fats	1.92	2.26	3.83	3.46	2.84	4.26	0.83	2.20	7.34	7.29	1.10	1.00
Crude fibres	41.27	49.18	59.66	9.61	11.14	11.04	46.30	36.72	9.59	9.32	54.60	59.00
Nitrogen-free extracts				56.84	47.26	37.67	31.54	31.85	52.42	50.88	34.58	30.36
Ash	7.87	7.56	7.76	6.34	8.26	10.40	5.95	7.48	7.77	10.13	4.34	4.38
Total nitrogen	7.67	6.56	4.60	3.80	4.88	5.86	2.46	3.48	3.66	3.58	0.86	0.85
Albuminoid nitrogen	5.15	4.08	4.34	3.05	3.85	4.18	1.10	1.47	3.37	3.10	0.54	0.57
Non-albuminoid nitrogen	2.52	2.48	0.26	0.75	1.03	1.68	1.36	2.01	0.29	0.48	0.32	0.28
In 100 parts of pure ash,												
SiO_2	3.71	1.07	3.44	2.64	4.68	1.90	1.19		1.35	1.42	0.94	1.40
SO_3	6.23	5.15	3.26	3.64	2.60	2.43	4.00		1.22	1.70	2.00	1.60
P_2O_5	14.34	12.68	13.86	17.90	14.60	20.40	14.64		6.41	6.56	8.90	7.80
K_2O	35.20	36.30	31.81	28.51	21.15	23.63	38.50		19.20	23.92	39.60	31.60
CaO	15.20	17.23	25.07	23.64	27.21	28.10	22.26		40.28	39.67	18.80	24.76
MgO	8.22	8.45	11.48	10.44	10.13	8.85	13.70		13.78	12.05	7.04	9.14

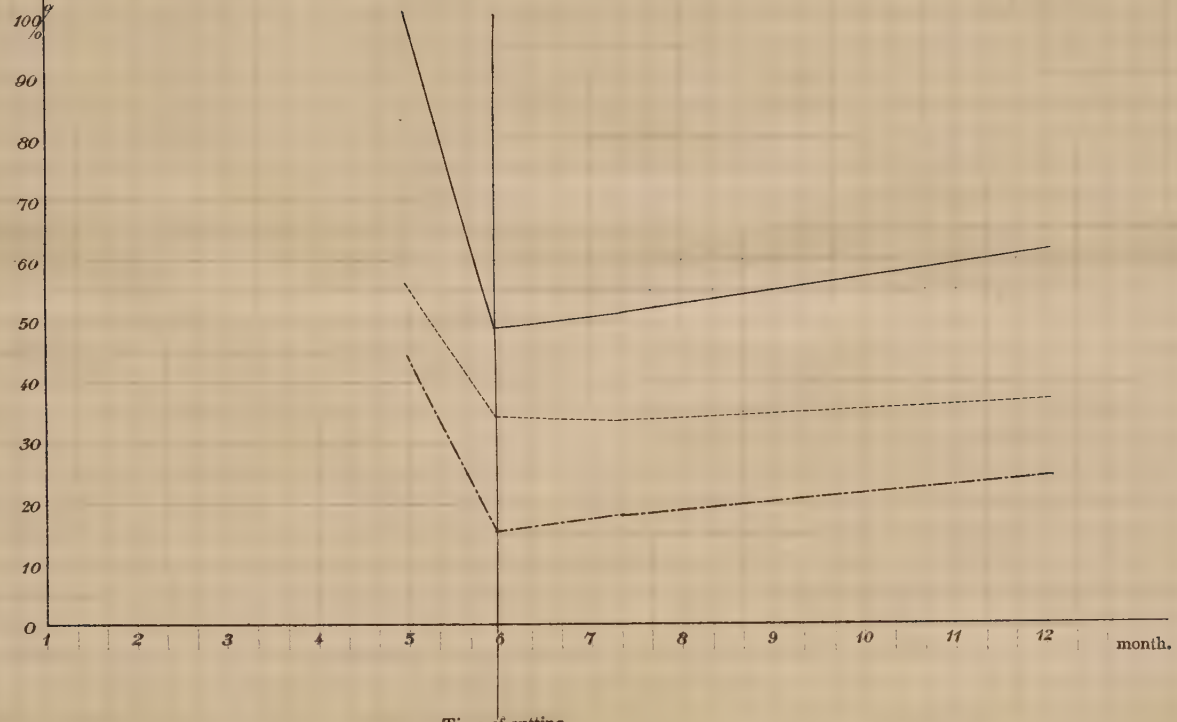
V. Showing the variation of Chemical composition according to seasons.

	Tsuruta		Hosoye		Takasuke					Jūmonji			
	May 6.	Oct. 15.	May 6.	Oct. 15.	May 22.	July 9.	Sept. 9.	July 9.	Sept. 9.	July 9.	Sept. 9.	July 9.	Sept. 9.
	Before cutting	After cutting	Before cutting	After cutting at autumn	Before cutting	After cutting	After cuttng	After cutting	After cutting	After cutting	After cutting	After cutting	After cutting
	Leaves	Leaves	Leaves	Leaves	Leaves	Leaves	Leaves	Stems	Stems	Leaves	Leaves	Stems	Stems
Average length of shoots								30.	180.			16.5	150.
Fresh weight of 1 shoot								5.45	101.			2.50	58.5
Dry weight 1 shoot								0.87	29.50			0.30	17.19
Fresh weight of 1 leaf	0.229	3.22	0.111	0.304	0.376	0.39	2.57			0.982	1.18		
Dry weight of 1 leaf	0.041	0.964	0.024	0.060	0.110	0.10	0.87			0.113	0.41		
Moisture	81.20	70.00	79.84	78.90	70.50	76.70	66.23	84.04	70.66	88.50	65.24	88.04	70.60
Dry matter	18.80	30.00	20.16	21.10	29.50	23.30	33.77	15.96	29.34	11.50	34.76	11.96	29.40
In 100 parts of dry matter,													
Crude proteids	48.94	26.88	41.00	33.00	23.75	30.50	22.88	15.38	5.38	36.63	22.38	21.75	5.31
Crude fats	1.92	5.80	2.26	5.19	3.46	2.84	7.34	0.83	1.10	4.26	7.29	2.20	1.00
Crude fibres	41.27	8.74	49.18	10.53	9.61	11.14	9.59	46.30	54.60	11.04	9.32	36.72	59.00
Nitrogen-free extracts		51.23		39.52	56.84	47.26	52.42	31.54	34.58	37.67	50.88	31.85	30.36
Ash	7.87	7.35	7.56	11.76	6.34	8.26	7.77	5.95	4.34	10.40	10.13	7.48	4.83
Total nitrogen	7.67	4.30	6.56	5.28	3.80	4.88	3.66	2.46	0.86	5.86	3.58	3.48	0.85
Albuminoid nitrogen	5.15	3.60	4.08	3.80	3.05	3.85	3.37	1.10	0.54	4.18	3.10	1.47	0.57
Non-albuminoid nitrogen	2.52	0.70	2.48	1.48	0.75	1.03	0.29	1.36	0.32	1.68	0.48	2.01	0.28

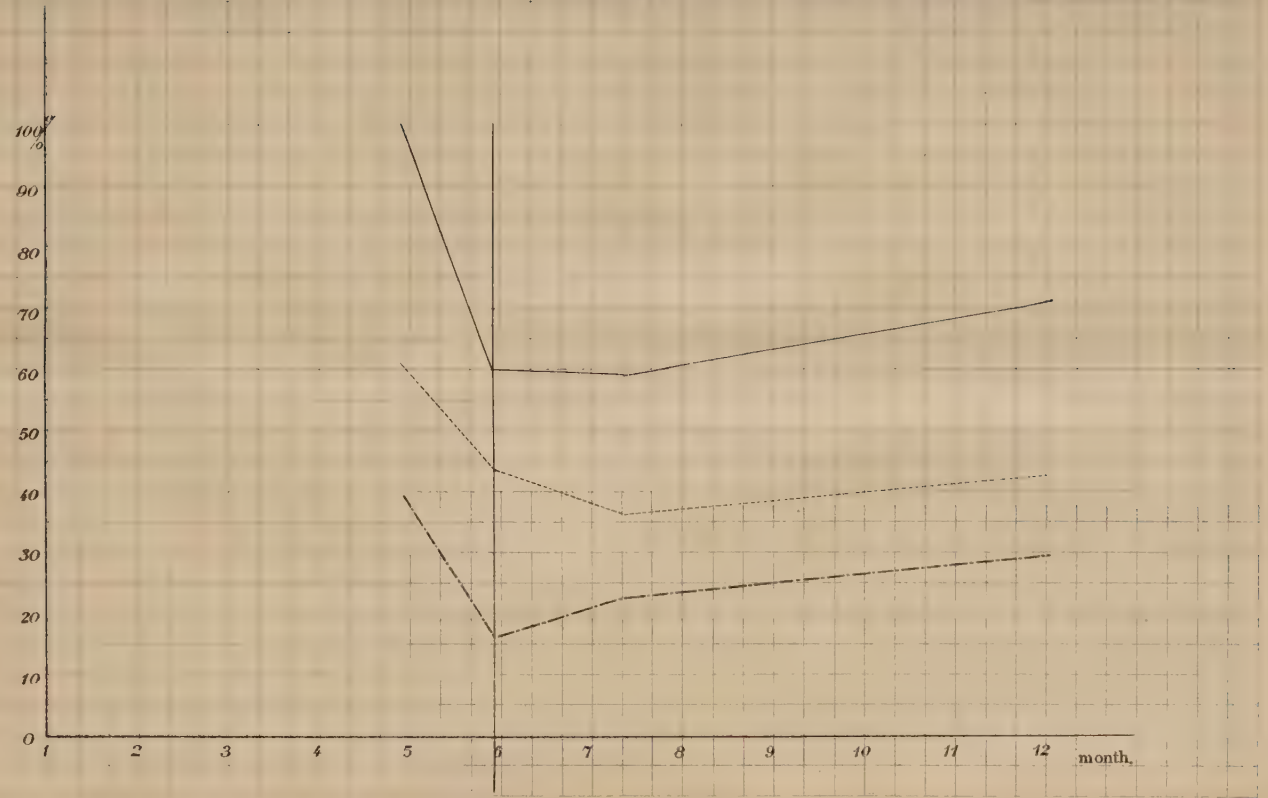
Takasuke. Root bark. Showing the variation of nitrogen compounds in one year;
(The total nitrogen on 28. calculated as 100)



Tsuruta. Root bark. Showing the variation of nitrogen compounds in one year.

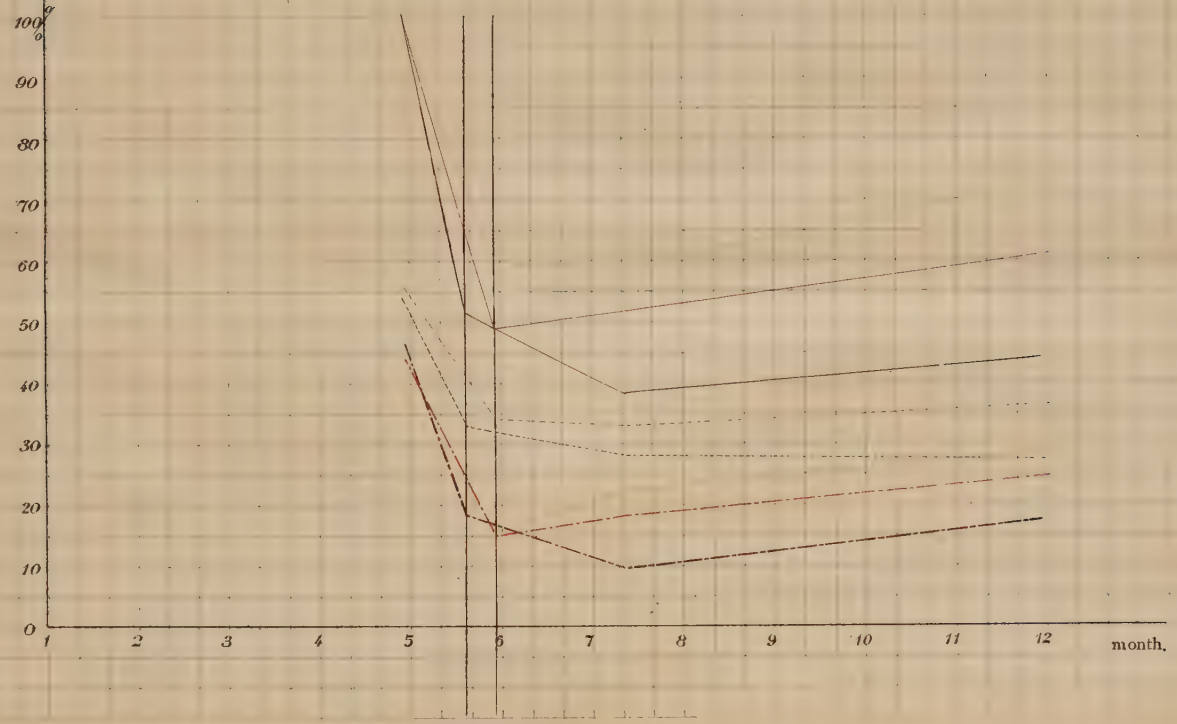


Yumonji. Root bark. Showing the variation of nitrogen compounds in one year.



Showing the relative rapidity (intensity) of the variation of nitrogen compounds in one year.
(Total nitrogen on April 28. calculated as 100)

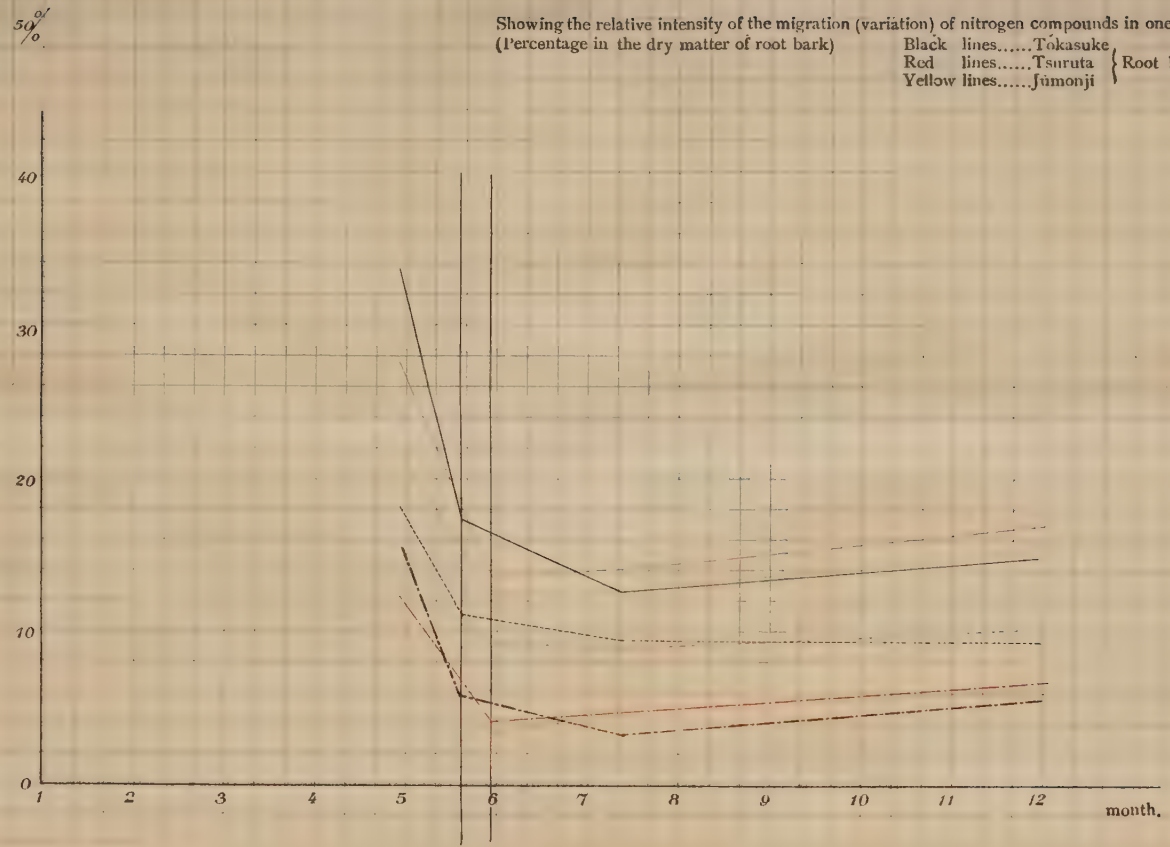
Black lines.....Takasuke
Red lines.....Tsuruta } Root bark.
Yellow lines.....Jûmonji



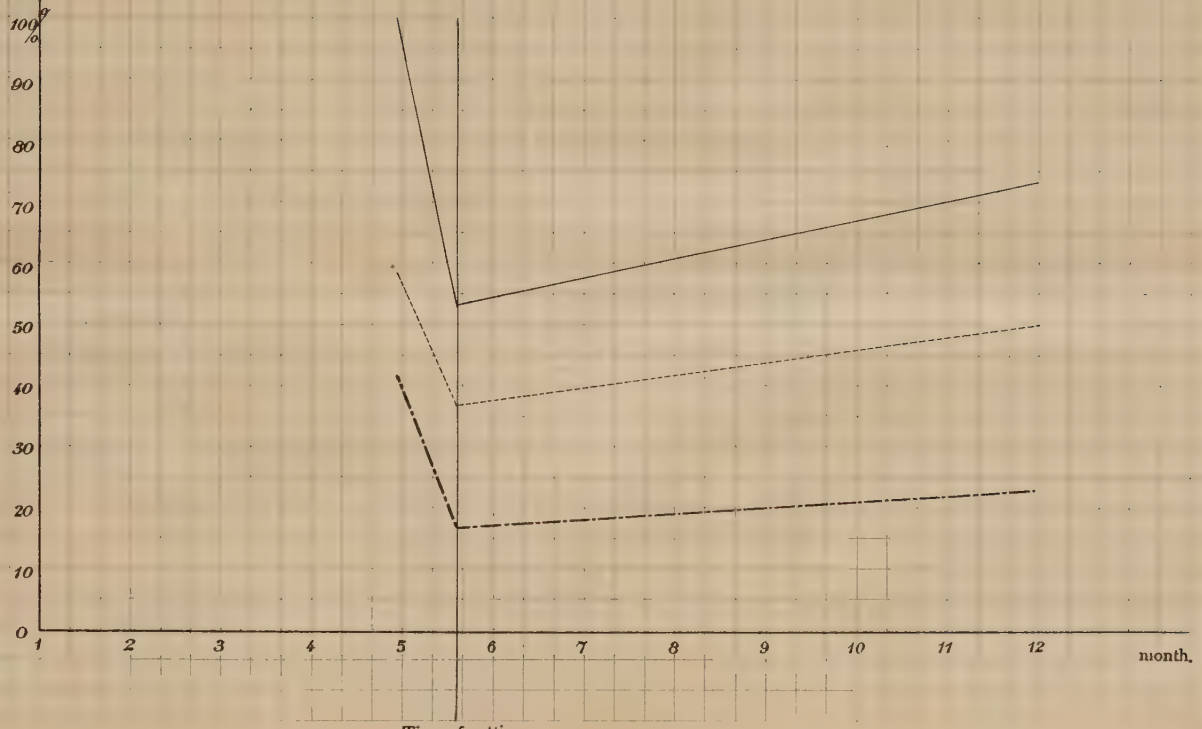
Time of cutting.

Showing the relative intensity of the migration (variation) of nitrogen compounds in one year.
(Percentage in the dry matter of root bark)

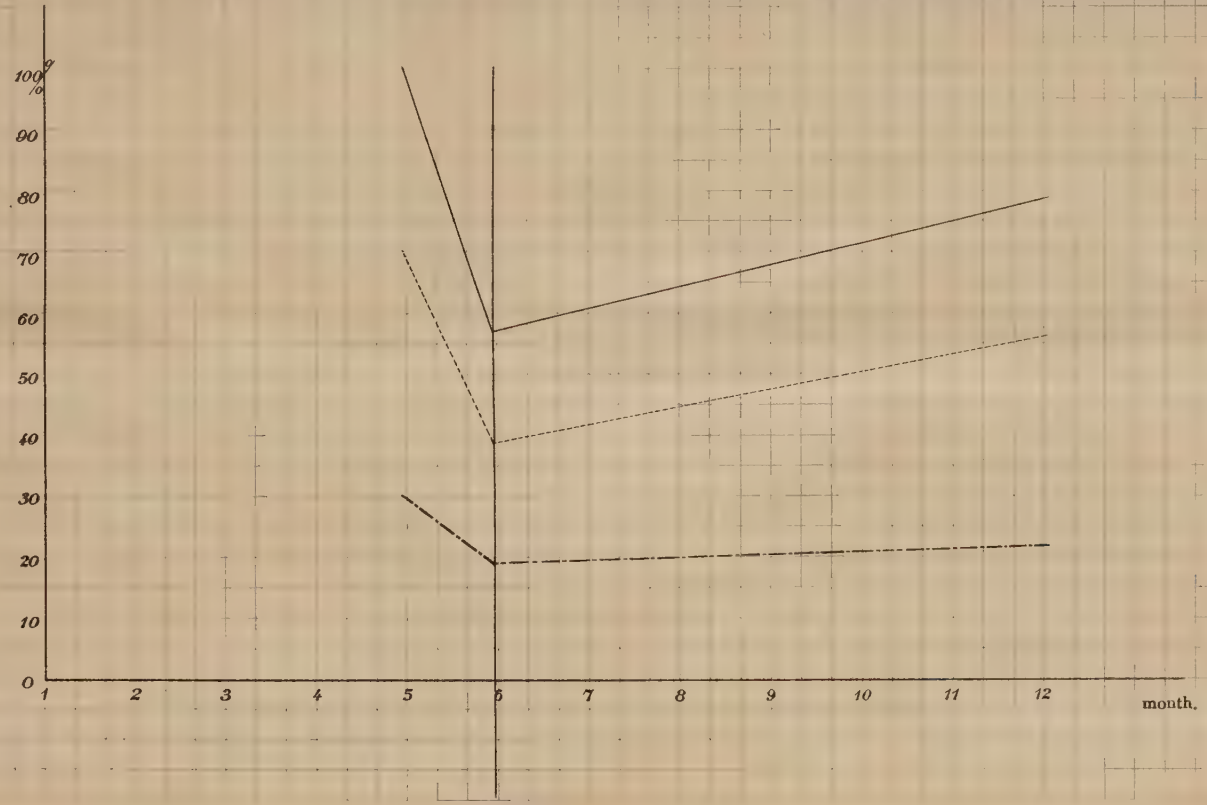
Black lines.....Tokasuke
Red lines.....Tsuruta } Root bark.
Yellow lines.....Jumonji



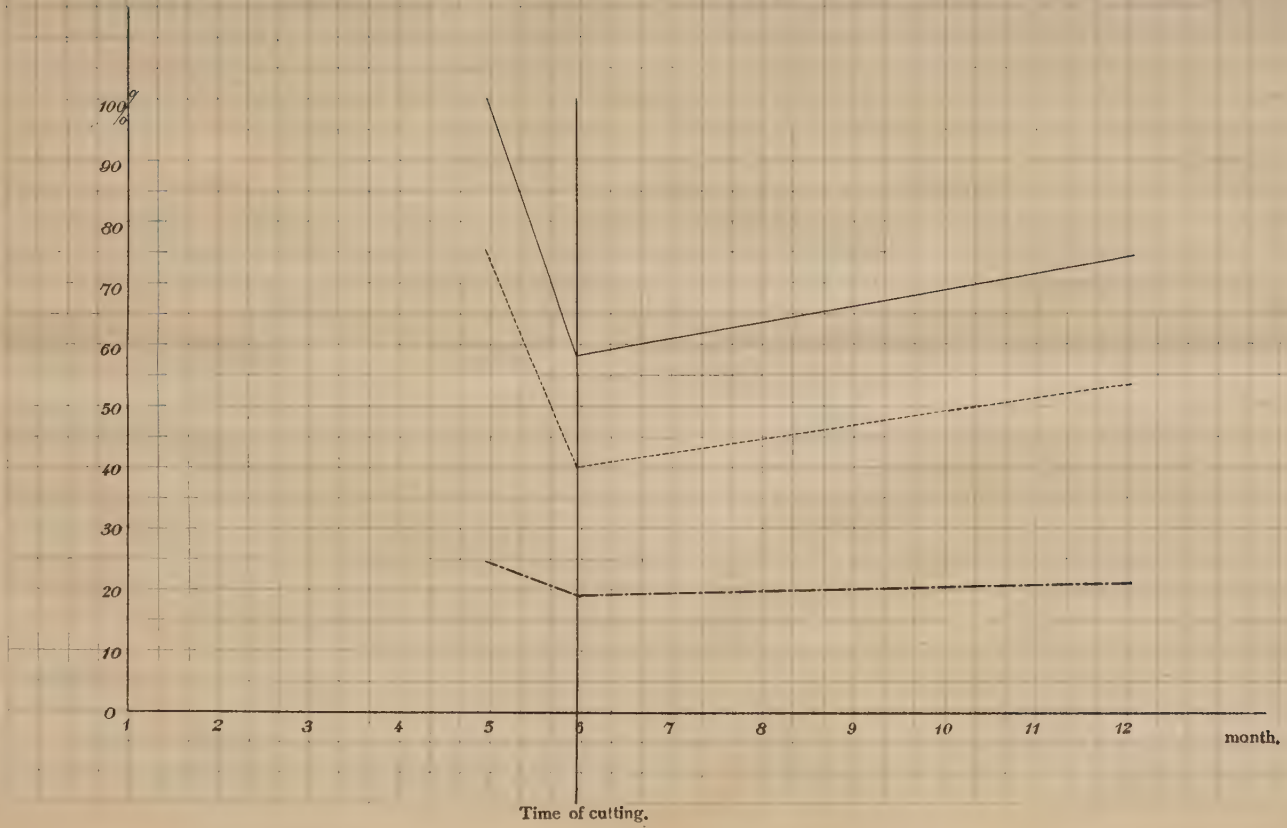
Takasuke. Stem bark. Showing the variation of nitrogen compounds in one year



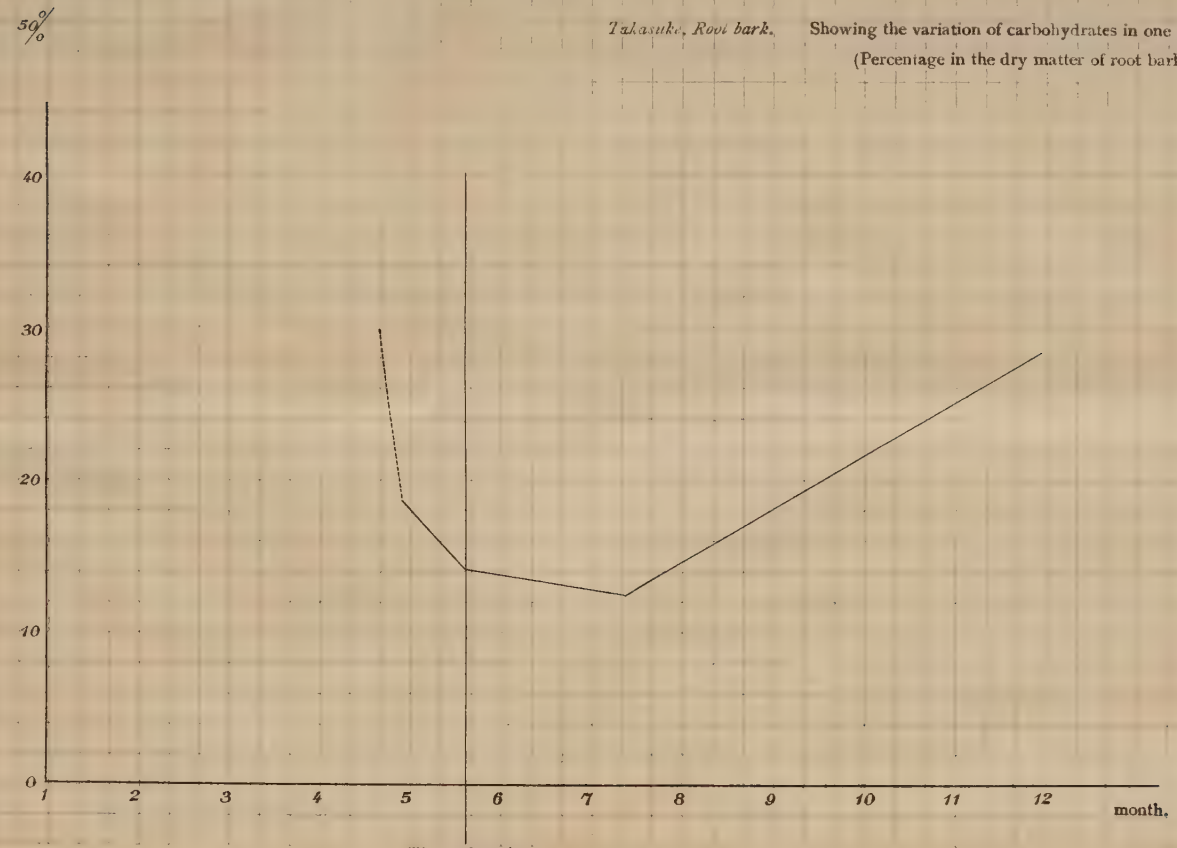
Tsuruta. Stem bark. Showing the variation of nitrogen compounds in one year.



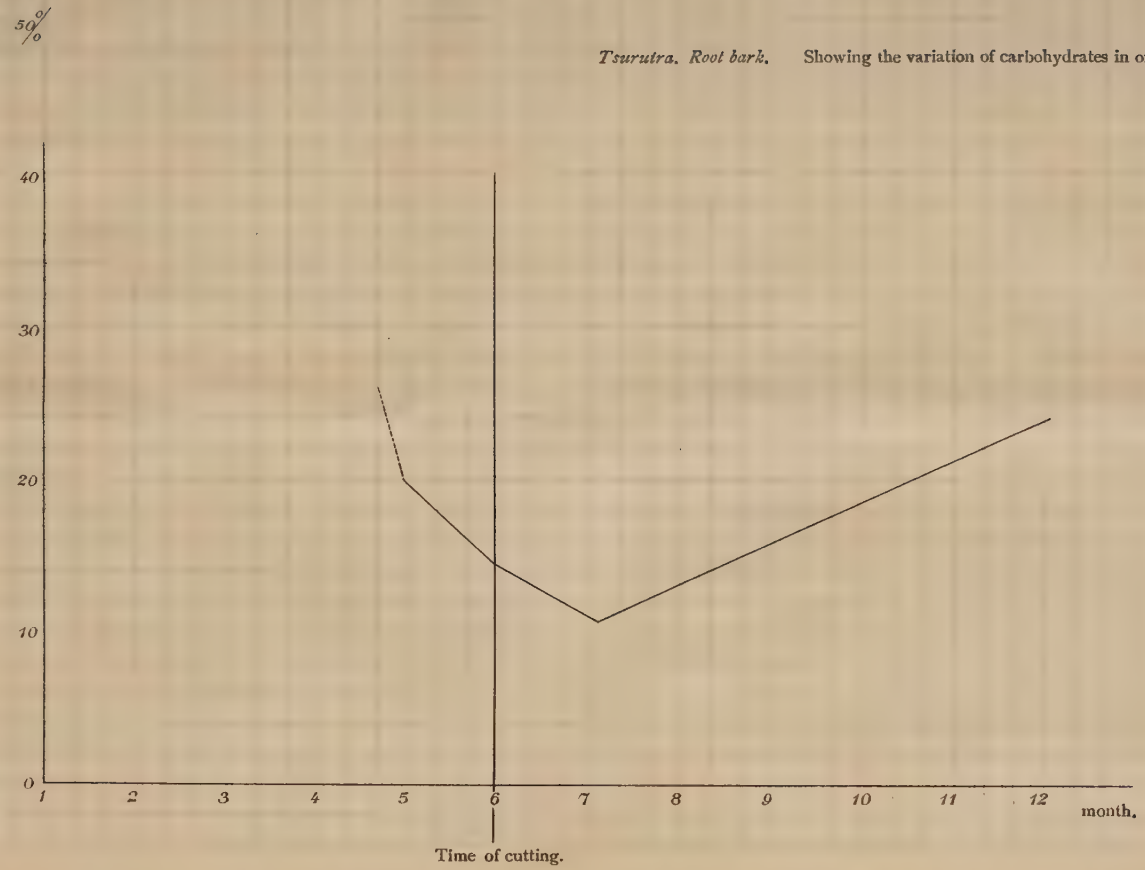
Jumonji. Stem bark. Showing the variation of nitrogen compounds in one year.



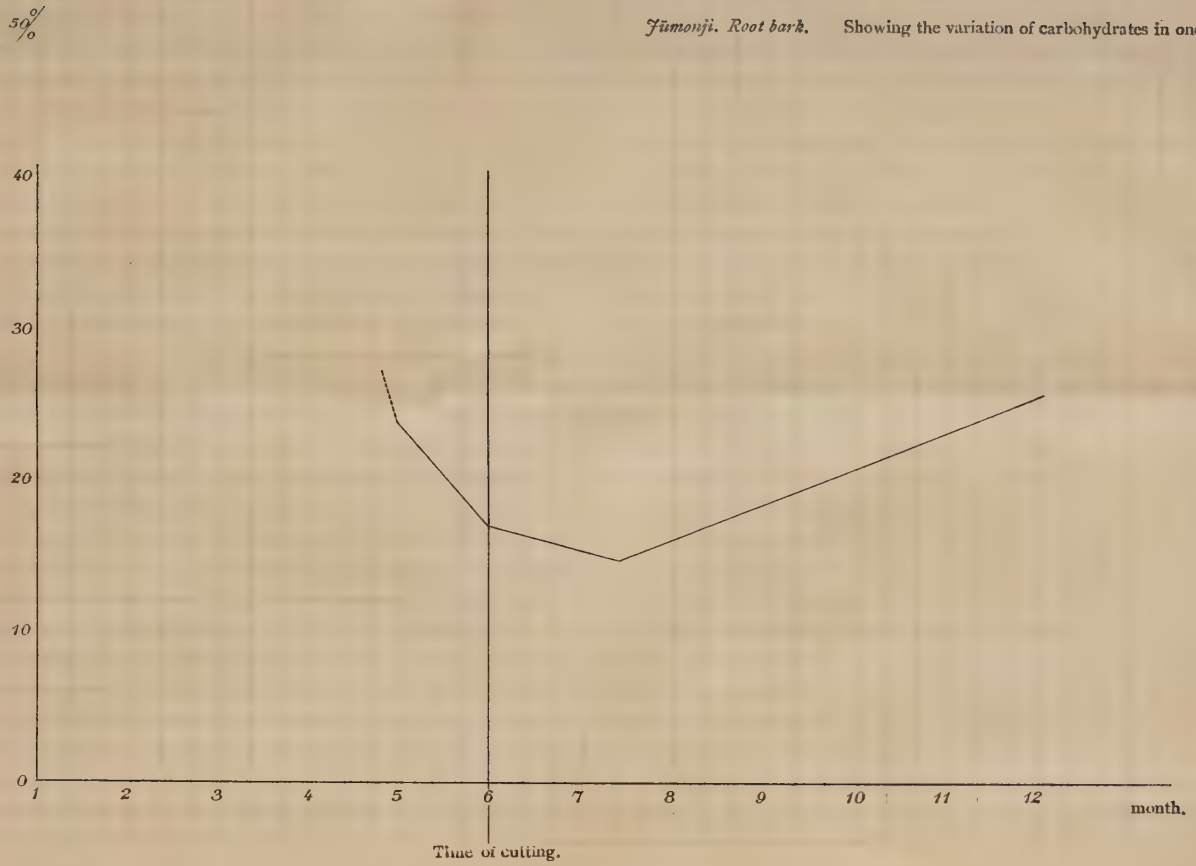
Takasuke, Root bark. Showing the variation of carbohydrates in one year.
(Percentage in the dry matter of root bark)



Tsurutra. Root bark. Showing the variation of carbohydrates in one year.

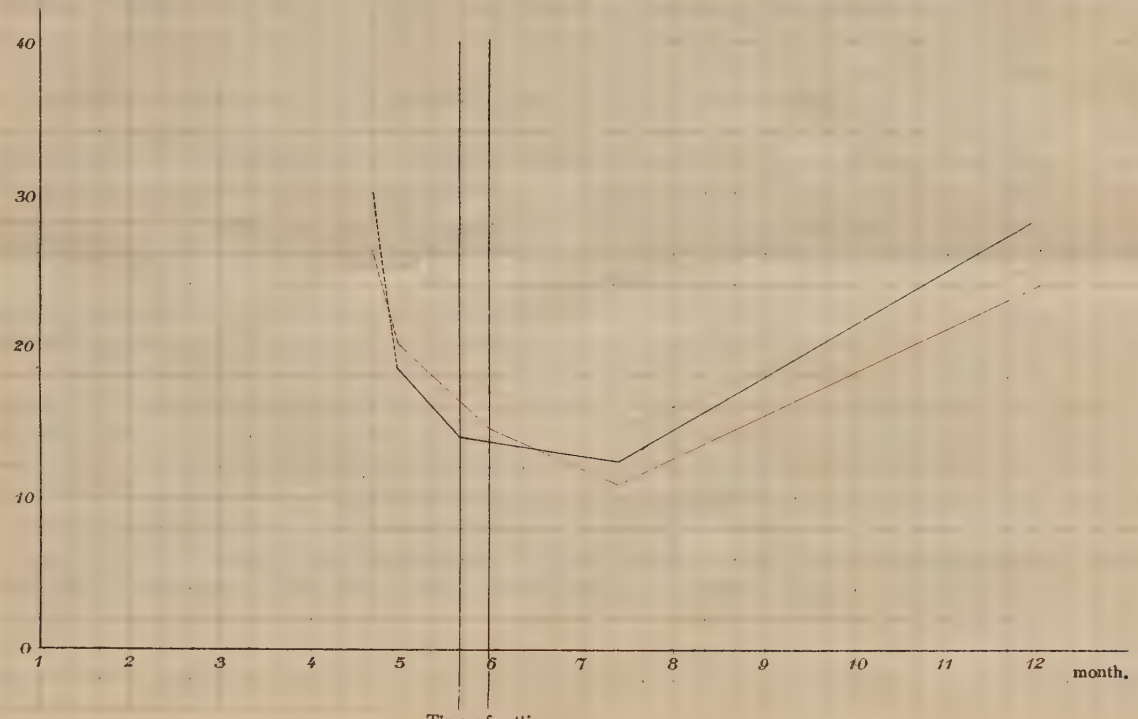


Fūmonji. Root bark. Showing the variation of carbohydrates in one year.



Showing the relative intensity of the variation of carbohydrates in one year.
(Percentage in the dry matter of root bark)

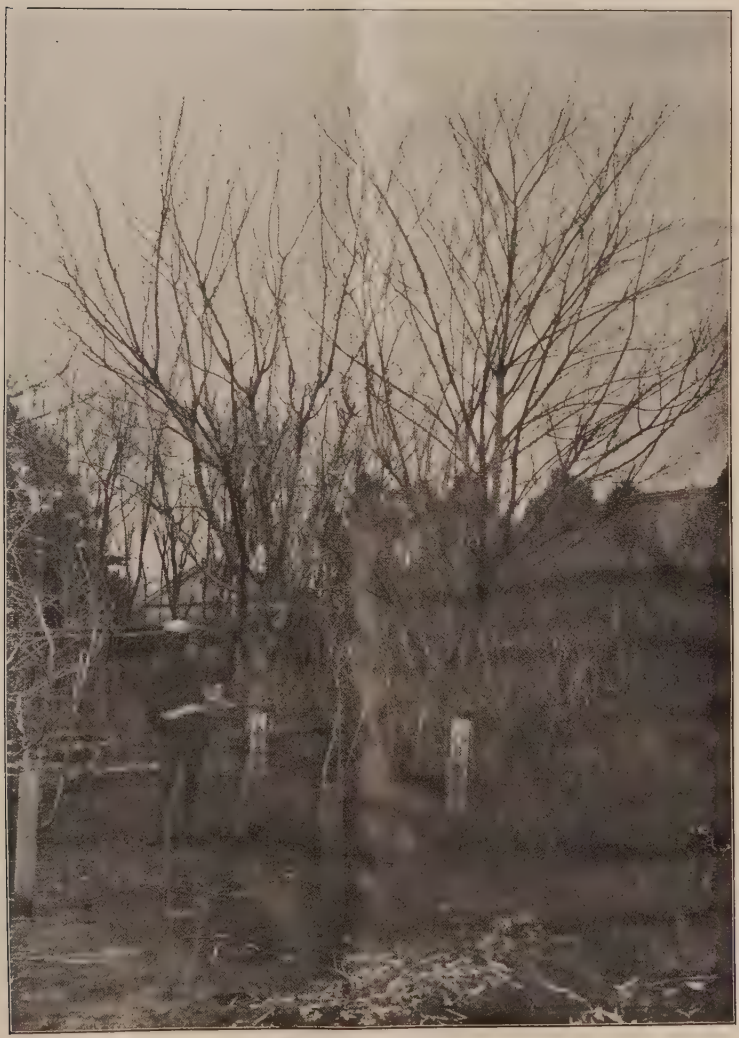
Black lines.....Tokasuke
Red lines.....Tsuruta } Root bark.
Yellow lines.....Jumonji



A healthy plant (low cutting).

A healthy and a diseased plant compared.

Diseased plants in winter.



Normal growth without cutting.

A portion of stems diseased by frequent plucking off of the leaves.

Plants diseased by plucking off of all the leaves.

Two stems of a diseased plant recovered by layering.

Diseased plants recovered by layering.

Diseased plants.

Plants diseased by cutting.

A healthy and a diseased plant compared.

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